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GUIDELINES FOR EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES

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IMPACTING ON WATER RESOURCES

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The public were notified of the proposed Guidelines for Evaluating Construction Activities Impacting on Water Resources through the Environmental Bill of Rights Electronic Registry and given the opportunity to comment in accordance with the Environmental Bill of Rights.

Preface

This document is an update of the MOEE's "Evaluating Construction Activities Impacting on Water Resources" published in 1976 and updated in 1984, at which time it was published as a series of five separate documents:

- Part 1 - Guidelines for Construction of Hydrocarbon Transmission and Distribution Pipelines Crossing Watercourses (1984)
- Part II -Guidelines for Highway and Bridge Construction(1984)
- Part III -Dredging Handbook (1991, revised 1994)
- Part IV -Marine Construction Projects (1986)
- Part V - Small Scale Projects (1986)

The current document updates and supersedes Parts I, II, IV and V. Part III, the Dredging Handbook, will continue to be distributed as a separate volume.

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Foreword

This document updates the series of construction handbooks issued by the Ministry in the mid-70's and revised during the mid-1980's to complement its policies on the protection of water resources from sediment and associated contaminants. The series of documents are titled "EVALUATING CONSTRUCTION ACTIVITIES IMPACTING ON WATER RESOURCES" and covered major land-disturbing activities associated with highways and bridges, oil and gas pipelines, marine construction and small scale riparian activities to enhance recreational uses of waterfront properties.

Planning for any type of development must incorporate an ecosystem approach if many of the past environmental problems are to be avoided. In short, this implies fitting the development into the existing environment without creating any major detrimental effects. A number of factors can be identified during the planning phase that will help to foster incorporation of ecosystem principles and reduce or eliminate the need for expensive control measures and post-construction remedial work. For construction related activities, these include:

1) Avoid areas of significant ecological value or sensitivity. In particular, wetlands, stream headwaters and major areas of groundwater recharge should be avoided.

2) Within an area, confine development and construction to the least sensitive areas. This will involve avoiding areas such as:

- *steep slopes*
- *areas of dense vegetation*
- *porous soils*
- *shorelines*
- *natural drainageways*
- *erodible soils*

Such areas can be accommodated by classifying them as part of the "greenways" (i.e., parks, natural areas).

3) Preserve natural landscapes and drainage systems as much as possible. Developments should be located away from natural drainage areas, maintaining these as "greenways".

4) Design the development such that it is appropriate for the type of terrain. In practice, this means matching the design of the development to the topography of the area.

5) Consider re-using fill materials wherever possible. The design should incorporate the principles of Reduce and Re-use such as to reduce or eliminate material destined for disposal outside of the development area.

6) Incorporate Best Management Practices into the design of the project, and before any work commences, ensure mechanisms are in place to guarantee that these practices will be followed during construction . Initial planning of the project should also ensure that any long-term maintenance programs designed into the project are adequately carried out.

Over the last decade many agencies with projects of a recurrent nature, such as highway construction, have tested and incorporated many new elements of best management practices into their design and construction process. As a result of this and the fact that better practices continue to evolve, this guideline document will not provide any specific advice on actual details of control measures. The main intent of this document is to note the environmental concerns and, where necessary, identify general principles that can be used to guide proper planning from a site selection perspective. While this document identifies general environmental concerns, it is not intended to be an exhaustive compendium of all requirements. Proponents are expected to consult the appropriate agency to determine its specific requirements. By contacting a local MOEE or MNR office, as well as the local Conservation Authority, the proponent will obtain information on procedures to follow and agencies that should be contacted.

1. INTRODUCTION

The guidelines, focusing mainly on erosion and sediment control during construction, represent one facet of the ministry's overall strategy to manage sediment so as to avoid many of the problems that are being experienced with contaminated sediments in our watercourses.

Most sediment concerns have arisen as a result of changes in land use. Development within urban and

agricultural areas has changed the runoff characteristics of streams and increased the availability of sediment material. Development has also enhanced the introduction of contaminants into the system, which have become a major concern associated with erosion and sedimentation.

Experience to date strongly suggests that the best strategy for managing sediment is to direct efforts primarily towards prevention of problems, i.e., to minimize sediment loss to the aquatic system. This is especially significant in light of the broad recognition that it is far more cost effective to prevent sediment problems from occurring than to clean up afterwards. Control of sediment loss to the aquatic system will result in benefits, such as a reduction in dredging activities at downstream locations, decreased accumulation of contaminated sediments at river mouths and harbours, and improved water quality particularly in relation to agricultural and urban runoff.

The best way to prevent sediment from entering and degrading watercourses is to control it at the source. Such controls must be planned in advance and implemented during the development phase. This will require a new attitude towards carrying out construction activities. The need to reassess the way development proceeds has been identified by a number of sources, notable among these the Royal Commission on the Future of the Toronto Waterfront. In its final report, *Regeneration: Toronto's Waterfront and the Sustainable City*, The Commission recognized that it will be some time before such changes in development become fully entrenched as standard practice. However, many concepts, currently considered as Best Management Practices are available to address the various concerns and provide the basis for future standardization of practices that will place major emphasis on preventive rather than remedial measures.

Equally important for effective sediment and erosion control is the need for regular inspection and maintenance of erosion and sediment control devices.

Erosion from land surfaces can contribute large quantities of sediment to watercourses. Erosion not only leads to accumulation of material in depositional areas, with such attendant effects as clogging of water intakes, destruction of habitat for fish and other aquatic organisms, and increased dredging, but in conjunction with discharges of contaminants can also lead to contaminated bottom sediments which are extremely problematic to clean up. Thus, effective erosion control can result in significant benefits in association with the protection of the aquatic ecosystem.

1.1 Federal Legislation

A number of federal acts apply to in-stream work. Some acts apply to urban development (e.g. Fisheries Act) and sediment control in general, while others apply to specific activities such as marine construction (docks, piers, causeways, lakefills, etc.), dredging activities, shoreline works, recreational (cottage) development.

Federal legislation can be divided into two groups: federal legislation applying to all proponents, and legislation and policies applying only to federal government departments.

<u>Environmental Assessment and Review Process</u>

The Federal Environmental Assessment and Review Process (EARP) is an Order-in-Council, intended to ensure that the impact of any federal project, program or activity is assessed early in planning stages before commitments are made. The process applies to any proposal undertaken or financed by the federal government, involving lands (including the offshore) that are administered by the Government of Canada, or which concerns any proposal which has the potential to cause an environmental effect on an area of federal responsibility.

The federal proponent initiating a project is responsible for assessing the significance of the environmental impacts and public concerns, and the implementation of required mitigative measures. In addition, the proponent must satisfy all other legislation or regulatory requirements related to the development and implementation of the project.

EARP is a 3 stage process: 1) The proponent undertakes an Initial Assessment (which may only be a simple checklist) outlining the environmental

impacts. If there are no significant impacts or public concerns the project may proceed, incorporating any necessary mitigative measures; 2) If Stage 1 has identified significant information gaps, or the project needs further assessment, the proponent conducts a more detailed review called an Initial Environmental Evaluation. If the proponent identifies no significant impacts, the project can proceed, implementing any mitigative measures; 3) If Stage 1 or 2 has identified significant impacts then the project is referred to the Federal Environmental Assessment and Review Office for formal review.

Although EARP is a self assessment process, Federal proponents may consult with Environment Canada to obtain environmental data, appropriate guidelines/regulations/codes, technical advice and comment to ensure a thorough review has been done.

Several pieces of federal legislation also have to be considered by the proponent. Some of the legislation has direct application only to dredging and dredged material disposal projects. Other acts may have broader impact or application under a variety of cases.

Pest Control Products Act

The Pest Control Products Act determines how a pesticide product is to be used in or near water. The Act determines label requirements and any precautions associated with the use of the product.

Canadian Environmental Protection Act

The Canadian Environmental Protection Act provides for the regulation of federal works, undertakings, and federal lands and waters, where existing legislation administered by the responsible federal department or agency does not provide for the making of regulations to protect the environment. In addition, there are provisions for the creation of guidelines and codes for environmentally sound practices and for setting objectives for desirable levels of environmental quality.

Migratory Birds Convention Act

The Migratory Birds Convention Act prohibits the disposal of any substances harmful to migratory birds in any waters or areas frequented by migratory birds. This would be applicable mainly in dredged material disposal and marine construction.

Fisheries Act

This act has broad applicability to sediment and erosion control, as well as to specific projects related to marine construction. Two sections of this Act are particularly relevant: Section 36 regulates the deposition of any substance (which would include sediment) which is deemed "deleterious", in waters frequented by fish. Section 35 regulates the alteration of fish habitat including alteration, disruption or destruction of habitat (where habitat is defined as "spawning grounds and nursery, rearing, food supply and migration areas on which fish depend, directly or indirectly, in order to carry out their life processes."). Although the administration of the Fisheries Act is the responsibility of the Department of Fisheries and Oceans, the administrative activity for Section 36 is carried out by Environment Canada and through a long established understanding Section 35 is administered by the Ontario Ministry of Natural Resources.

Navigable Waters Protection Act (NWPA)

The NWPA prohibits any work on, in, upon, under, through or across a navigable waterway. "Work" has been defined to include the dumping of fill or the excavation of materials from the bed of navigable waters as well as a variety of marine construction projects such as lakefills, pier construction, etc. An application for exemption is required for such projects, including dredging or disposal operations. Prior to granting the exemption, Transport Canada reviews the implication of the project for potential impact on navigation.

Canada Shipping Act

The Canada Shipping Act regulates the discharge from ships (open water disposal) of any pollutant specified in regulations of the Act. A ruling under Section 728 of the Act may be required.

Great Lakes Water Quality Agreement

The Great Lakes Water Quality Agreement is an agreement between Canada and the United States to restore and enhance the water quality of the Great Lakes. Annex 7 of the Agreement relates specifically to dredging activities and specifies that the two

governments will develop and implement programs and measures to ensure that dredging activities will have a minimum adverse effect on the environment. Annex 14 of the agreement provides for the governments, in cooperation with State and Provincial Governments to identify the nature and extent of sediment pollution in the Great Lakes System and subsequently develop and evaluate methods to remedy such pollution.

1.2 Provincial Legislation

Environmental Assessment Act

The Environmental Assessment Act requires that proponents of major projects outline the details of the project and identify how construction, location and ultimate utilization will affect current and future uses of that area. Water quality effects, biological effects, and social and economic factors must be considered.

Environmental Protection Act

The Environmental Protection Act regulates the "spilling" or discharge of pollutants into the natural environment, and protects human health and plant and animal life against injury and damage. This may include not just chemical contaminants but soil and sediment as well. This, and the following act, have broad applicability to construction activities.

Ontario Water Resources Act

The discharge of any material into water that may impair water quality or cause injury to any person, animal, bird or other living thing is prohibited by the authority of the Ontario Water Resources Act.

Pesticides Act

The Pesticides Act regulates the sale, use, and application of pesticides within the province.

Beds of Navigable Waters Act

Title to the beds of navigable waters is restricted through grants by the Lieutenant-Governor. Ownership of lands bordering navigable waters does not provide right of use of the beds of those waters.

Public Lands Act

The management, sale and disposition of public lands, which includes the beds of most lakes and rivers as well as seasonally flooded areas, is controlled by the Public Lands Act. The Ontario Ministry of Natural Resources may define zones as open, deferred or closed for disposition. The Public Lands Act also regulates development, construction, or alteration of any public shorelands and this part may apply to a broad range of projects including both commercial and residential construction activities (e.g., dredging and filling, dock construction). All shoreline construction work will require a Work Permit issued by MNR under this legislation.

Conservation Authorities Act

The restricting or regulating of water through the construction of dams or diversions or depressions in rivers and streams and the placing and dumping of fill within the watershed is placed under the jurisdiction of the local Conservation Authority.

Beach Protection Act

The Beach Protection Act refers to taking of sand from the bed, bank, beach, shore or waters of rivers, lakes and streams and requires a license from the local Ministry of Natural Resources District Manager.

Drainage Act

The Drainage Act provides information on procedures for the construction, improvement and maintenance of drainage works.

Public Health Act

The Public Health Act is concerned with public water supplies and maintaining their quality to protect human health and assures that projects not impinge on the operation of water treatment facilities.

Lakes and Rivers Improvement Act

Approval for any work that consists of forwarding, holding back or diverting water (e.g., construction, repair, reconstruction or removal of dams, bridges, culverts, drainage outfalls) is required from the Ontario Ministry of Natural Resources. Furthermore, the deposition of any substance or refuse into a lake

or river or on the shore is prohibited by this Act.

Planning Act

The Provincial Wetlands Policy Statement, which was issued under the Planning Act addresses wetland protection and management within the land use planning process.

Mining Act

All aspects of mining activities within the province are regulated under the Mining Act.

1.3 Municipal Legislation and Policies

These will affect a project where shoreline or upland disposal is to be used. In these cases, municipal zoning or planning guidelines may have to be considered and taken into account. Since each municipality may have different requirements, the proponent is advised to contact the appropriate municipal office during the initial screening stage of the project. Contacting the municipal office will also permit the proponent to assess the need for public information sessions to facilitate public acceptance of the disposal facility.

Topsoil Preservation By-Laws

A number of municipalities have passed or will be passing, By-Laws that restrict the removal of topsoil. In many cases, the proponent, before being granted a permit will have to present a detailed erosion and sediment control plan.

2 IMPACTS OF EROSION AND SEDIMENTATION

2.1 Erosion

The loosening and transport of soil through the action of wind, water or ice, and the deposition of this material in new areas forms the processes of erosion and sedimentation. While these are natural processes that over millennia have come to shape the earth itself, they are also a major consequence of construction and associated land use activities. Through such activities the process of erosion can be considerably speeded up.

The process of erosion consists of three separate phases:

1) detachment: this is the loosening of the soil particles and depends on soil characteristics such as strength of cohesive force and particle size.

2) transport: the movement of the soil particles from their place of detachment.

3) deposition: the coming to rest of the particle when the transport forces are no longer sufficient to keep it moving.

For the purposes of this document, water is considered as the major agent effecting erosion and sediment transport.

When rain falls over an area, some of it is absorbed by the soil. The ability of the soil to absorb water is determined by its infiltration rate, which in turn depends on a number of factors including: soil texture, soil structure, vegetation cover and moisture content.

When the soil has become saturated and can no longer absorb water, or when the soil cannot absorb water fast enough, the excess water drains across the surface of the ground. The flow of water over land without depressions for water to accumulate (i.e. channels) is termed "overland" or "sheet flow". The velocity of overland flow depends on the slope of the land - the greater the slope, the higher the velocity of the flow. In most cases, the flow will quickly coalesce into small depressions and become rill and finally gully flow. While rill flow does occur on natural landscapes, it is most evident on disturbed surfaces such as newly cut roadbanks, embankments, ploughed fields, etc. The rills in turn may converge to form larger depressions such as gullies.

During overland flow, erosion may occur when the energy of the moving water is sufficient to overcome the inertia of the soil particles (the amount of energy required depends on the size of the particle, the strength of attraction to other soil particles and the particles are suspended by the water. These suspended particles may in turn collide with and dislodge other

particles in their path which are also carried along with the flow.

The distance the particles travel will depend on the slope of the land and the duration of the rainfall. On steep terrain, or during prolonged rainfall events, the particles may be carried directly to nearby watercourses. If the rainfall is of short duration, entrained particles may only be carried short distances before being deposited.

The ability of water to remove the soil particles is greatly influenced by vegetative cover. Vegetation serves to bind soil particles together through the root system and also provides a protective cover for the soil surface. Vegetation such as grass, tends to slow down the flow of water and may increase infiltration by retarding the rate at which water moves across the soil surface. Tall vegetation, such as trees, can break the impact of raindrops and also slow down the rate at which the water reaches the surface, thereby also enhancing soil infiltration.

Maintaining and retaining vegetative cover is an inexpensive and effective way of preventing soil loss and should be factored in all construction plans.

Sediment and Erosion Control

Planning Considerations

Effective sediment control involves addressing those activities that may result in increased erosion and sedimentation in both the planning and the construction stages.

Comprehensive planning during the initial design stage of a development can be the most cost effective erosion and sediment control mechanism.

- developers and local agencies need to consider the proposed development(s) in a regional/watershed context, taking into account the cumulative effects of development within the watershed.

- the design stage needs to consider alternatives that can reduce those problems leading up to erosion and sedimentation - for example, incorporation of changes in design of residential subdivisions that retard runoff and increase infiltration.

- the components of aesthetically pleasing design (i.e., incorporation of "greenspace", maintenance of a natural landscape, recreational areas) are often the same principles that promote effective sediment control.

- a development project, be it a residential area, a bridge, highway, or an industrial development, should not be considered in an isolated context. Poor design or management practices in a given watershed can result in a number of downstream effects that can be compounded by other or similar developments within the watershed.

- sediment control measures to be used on a particular site must be geared to control both the short-term impacts during the construction phase, and also address the long-term effects. Most construction activities will require a 'sediment control plan' in order to obtain the necessary approvals from the relevant agencies. The planning and design phase of the construction project is the only period in which these controls can be adequately worked out.

- Regular inspection and maintenance of sediment controls needs to be incorporated into the original design of the undertaking and sufficient funds need to be allocated for the proper maintenance of such measures.

In the initial planning stage, a number of factors can help to reduce or eliminate the need for more expensive control measures and post-construction remedial work:

- Avoid areas of significant ecological value or sensitivity, in particular, wetlands, stream headwaters and major areas of groundwater recharge.

- Confine development and construction to the least sensitive areas. This will involve avoiding areas such as:
  - steep slopes

- areas of dense vegetation
- porous soils
- shorelines
- natural drainageways
- erodible soils

Such areas can often be accommodated by classifying them as part of the "greenways" (i.e., parks, natural areas).

- Preserve natural landscapes and drainage systems as much as possible. Developments should be located away from natural drainage areas, maintaining these as "greenways".

- Design the development such that it is appropriate for the type of terrain. In practice, this means matching the design of the development to the topography of the area.

- Consider re-using fill materials wherever possible. The design should incorporate the principles of Reduce and Re-use in order to reduce or eliminate material destined for disposal outside of the development area.

The maintenance of infiltration is an important long term consideration in stream flow, particularly where large scale development is considered.

Most sediment and erosion control measures depend on controlling the velocity of the overland flow through changes in slope and vegetation. Where this is not possible, the provision of areas such as settling ponds can result in removal of material from transport before it reaches the watercourse.

In undertaking sediment and erosion control there are always a number of factors, such as rainfall duration and soil characteristics, that cannot be controlled. However, a number of critical factors such as slope and vegetation cover can be controlled, and these form the basis of effective erosion control.

Understandably, prevention is not always possible and structures to contain and remove sediment, such as the creation of settling ponds or the installation of sediment containment barriers, will be necessary.

2.2 Instream Erosion

Natural vegetative cover serves to increase infiltration of water into the soil. Increased infiltration in turn serves to decrease the amount of rainfall draining to the stream by reducing surface runoff, which can reduce instream erosion as well as surface erosion. Infiltration also serves to maintain the base flow of the stream.

Instream erosion is the widening or deepening of a stream channel by a) corrasion - mechanical wearing by water and bedload materials (corrasion is the most significant method of in-stream erosion); b) corrosion - dissolution and removal of particles through chemical action; c) cavitation (a form of corrasion)- due to high velocities around constrictions, e.g. bridges.

Streams with low banks, heavy vegetation, or rocky banks are resistant to corrasion from water. Channels may be deepened by corrasion i.e., the abrasive action of water and bedload materials. The deepening may result in higher streambanks which are then highly susceptible to undercutting and slumping.

The infiltration of water into the soil during rainfall can have a direct influence on instream erosion as well. In an undisturbed area, the flow of water overland is influenced by the infiltration rate. Where infiltration has been reduced through removal of vegetative cover, the rainfall drains rapidly overland. Thus, a larger volume of water will reach the watercourse in a relatively shorter period of time. Road runoff, for example, will increase the discharge of the stream which in turn will increase the corrasive action of eroded sediments, water, and bedload in the stream. The net effect can be increased sediment accumulation at downstream locations.

The sediment material carried by a stream (fluvial sediment) can be divided into a) suspended load and b) bedload. The difference between the two is a factor of flow velocity. Suspended load consists of particles small enough to remain in suspension during flow. Bedload consists of larger particles that are too heavy to be suspended and are moved mainly through rolling or bouncing on the bottom. The distinction between the two will vary depending on the flow of the stream.

In order to obtain the maximum attainable use of

a watercourse it is essential that its integrity be maintained. Small changes to natural processes can result in major detrimental changes to a watercourse. It is therefore essential that efforts be made to minimize losses of sediment from construction to our watercourses. In many cases the changes created are damaging and irreversible.

2.3 Effects of Sediments on Physical/Chemical Quality and Water Use

a) Sediments introduce nutrients, salts, metals, pesticides and other persistent organic compounds sorbed to soil particles into the aquatic environment. The finer sediment particles, by virtue of their greater surface area to volume ratio adsorb relatively greater quantities compared to larger sediment particles.

b) Sediments lower the recreational and aesthetic value of the watercourse due to turbidity and associated contaminants.

c) Sediments may impair water quality for:
   1) agricultural use - may cause damage to water pumps, etc.,
   2) water treatment plants - such plants are designed to remove a certain amount of sediment and when this limit is exceeded, plant operations can be disrupted resulting in increased costs, temporary shutdowns, etc.
   3) Industries - industrial processes that use water in their production/processing operations can be affected through poorer quality products, equipment failures, etc.

d) Changes in capacity of water storage structures such as reservoirs, through settling of particles.

e) Changes in runoff regimes (discharge), resulting in changes in flood patterns, stream channel movement/ alteration/ modification.

2.4 Effects of Sediment on the Abiotic Water Environment

Potential effects of increased sediment on physical/chemical components of the aquatic environment include:

- organic enrichment
- effects on water uses (water intakes)
- accumulation of sediment at river mouths and harbours
- co-accumulation of contaminants

Both short-term and long-term effects on the aquatic environment are associated with the construction and operational phases of:

- watercourse crossings for roads, bridges, pipelines and transmission lines.
- urban development (residential and commercial/industrial)
- forestry practices (access roads, cutting practices)
- mining activities
- agricultural activities

A number of these activities, such as urban development, mining and agriculture can also contribute contaminants to the water and sediments.

<u>Short-Term Effects</u>

Short-term effects can be due to both instream and nearstream construction activity and are most often due to the construction phase itself. Since most construction activity is concentrated in one area, potential concerns include:

- introduction of large quantities of sediment into the watercourse almost instantaneously which can blanket the channel bed and fill the water column with suspended particles

- potential to alter the light, temperature and water chemistry regimes of the watercourse.

- potential to alter biological communities (at least temporary, and sometimes permanent, loss of benthic and fish communities)

<u>Long-Term Effects</u>

Long-term sediment effects tend to be related to changes in land use resulting from construction activity and are more often related to the actual design of the project. Examples include:

- road construction which can result in increased surface runoff and potential increase in some contaminants (from de-icing and combustion by-products)

- urban development can lead to increased runoff due to changes in infiltration area, resulting in more rapid surface runoff. This can result in channel modifications, increased in-stream erosion, changes in flooding, frequency of dredging, and changes in water quality.

These activities can result in alteration to the regime of the watercourse, often through changes in the watershed, which can result in changes to local bed and bank morphology and composition (i.e. altered depth, width, gradient, size of bed material).

Morphological changes to the stream bed or bank can induce altered flow patterns which in turn disrupt the local scour and fill (i.e. short-term in-channel erosion and deposition) equilibrium. In this way the effects can be transmitted both upstream and downstream, potentially altering conditions well removed from the point of initial disturbance.

The composition of bed and bank material can be altered by the introduction of imported backfill material, deposition of trench sediments, and the action of altered flow patterns.

The potential for long-term effects can be minimized through careful attention to site rehabilitation. The goal should always be to restore all disturbed areas at the construction site to as near preconstruction conditions as possible.

2.5 Impacts on Aquatic Biota

In some cases pesticides, oil and grease, and other hazardous chemicals may be introduced to watercourses through construction or land use activity. They may be introduced through direct losses to the watercourse, or indirectly through spills on soils or exposure and subsequent erosion of previously contaminated soils.

Although the risk of contaminant uptake by organisms and subsequent biomagnification through the food chain is reduced in those instances where contaminated sediments have been covered by clean deposits, in-stream construction activity that disturbs the sediment, such as trenching, excavating, or dredging, may reintroduce the contaminated material into the water column, making it directly available to aquatic biota. In-stream construction (e.g., construction of bridge footings, streambank alterations) that changes the flow pattern of the river may also lead to erosion and resuspension of contaminated material from previously deposited material.

The sedimentation effects of construction can result in adverse impacts on aquatic biota. Sediments can affect:

(a) primary productivity
(b) benthic organisms; and
(c) fish.

In some cases, construction activities will use considerable quantities of water, which are often pumped directly from adjacent watercourses. In all cases, sufficient flow should be maintained to protect biological resources as well as meeting all established downstream water uses.

Interference with the functioning of any part of the system has the potential to disrupt the stability of the entire system.

Effects on Primary Productivity

The photosynthetic production of organic matter by green plants, such as plankton and algae (autotrophs), is referred to as primary productivity. The increased turbidity which results from the introduction of suspended sediment into the water column attenuates the penetration of light and curtails photosynthesis, thereby adversely affecting one of the basic food sources of the aquatic environment. In those cases where in-channel vegetation is affected, a loss of protective cover may also result.

In order to prevent unnecessary adverse impacts upon primary productivity, every effort should be made to reduce the extent and duration of turbid conditions. This is best achieved by limiting construction in and adjacent to watercourses to the absolute minimum. In addition, sediment control measures that reduce the loss of sediment to watercourses should be used whenever possible.

Effects on Benthic Organisms

The survival of benthic organisms depends upon the preservation of the watercourse substrate as suitable habitat. The most severe impact of sediment on the benthic community is the blanketing of the channel bed as a result of rapid sediment deposition. This either destroys the organisms or causes them to drift downstream (Hynes 1973). These bottom dwellers form a vital link in the aquatic food chain and elimination of these organisms can result in an overall reduction in productivity as dependent predators are forced to abandon regions thus affected.

Most sediment problems related to construction are relatively short-term and can be overcome. Short term impacts can often be tolerated by benthic organisms. Re-colonization of areas can occur relatively rapidly once the source has been stopped (i.e. when construction has been completed) though in some cases the original benthic community structure may be altered.

Effects on Fish

Increased turbidity adversely affects those species of fish which rely on sight for feeding and escaping from predators. Excessive sediment levels may also affect the respiratory mechanism of fish through clogging or abrasion of the gills, although many species of adult fish are able to withstand high levels of suspended sediment for extended periods of time by exuding a protective mucous on their skin and gills. However, this does not assure survival, since the production of this mucous depletes metabolic reserves at a time when feeding is inhibited by turbid conditions (Illinois EPA 1979).

Sediment can also clog the interstices of the substrate in fish spawning areas, thereby interfering with the normal exchange of water which replenishes the oxygen supply and removes accumulated waste products. This impact can be lethal to emerging young (Illinois EPA 1979).

The loss of reproductive capacity through physiological stress, loss of spawning beds, and destruction of eggs or fry may result in a more significant negative impact on fish species than the direct short-term abrasion and clogging effects on adult fish. Although the damaged habitat may recover eventually, recolonization may be by less desirable species.

Effects of development and construction are not limited to the effects of sediment loss to the water. Changes in vegetative cover, infiltration and surface runoff can alter existing habitat to the point where it becomes unsuitable for fish.

2.6 Impacts on Watercourse Uses

In addition to disrupting aquatic biota, the turbidity resulting from construction-related sediment loads may also adversely affect various types of watercourse uses. These are summarized below.

Disruption of Ground and Surface Water Quantity

Alteration of ground and surface water runoff through changes in infiltration can change the discharge pattern of the receiving stream. Rapid runoff can result in more dramatic peaks in runoff, as where storm water is rapidly discharged to the receiving water. This can heighten stream erosion, with subsequent scour and accumulation downstream. This can also lead to morphological changes in the stream course that may result in loss of property.

Changes in land use can result in major alterations in infiltration and surface runoff patterns. Removal of vegetative cover, reduction in surface area available for infiltration, channelization of drainageways can all increase storm runoff and decrease infiltration and groundwater recharge.

Construction activities such as dewatering of trenches, cut and fill operations, blasting, and the reduction of infiltration due to surface compaction, paving, etc., can disrupt the pattern of ground and surface water flow by altering ground water levels.

Flow diversion for instream work may substantially alter the pattern of streamflow and result in such negative effects as increased scour (in-channel erosion) within the diversion, increased sedimentation downstream, or cessation of flow during low flow periods.

Damage to Watercourse Bed and Banks

Blasting operations and the operation of heavy equipment on the bed and banks of watercourses can cause significant changes in channel morphology. This will alter the watercourse flow pattern, and may result in effects such as scour, increased concentrations of suspended solids, and blanketing of the channel bed.

The removal of bankside vegetation can lead to increased streambank erosion; an increase in water temperatures, and; reduction or elimination of an important energy source for the stream biological community.

Impaired Municipal/Industrial/Private Water Supplies

Depending on the extent and duration of turbid conditions and associated contaminants, and the treatment facilities available, there may be a temporary impairment or loss of water supply for municipal and/or industrial and other private users. In some instances increased operational costs may result (e.g. increased backwashing) and equipment or facilities may be damaged, creating a longer term disruption.

Flow Obstruction/Increased Flood Risk

Flow obstruction results from the formation of bars due to sediment deposition and can occur in channels of all sizes and types. The reduction in channel capacity through sediment accumulation may also be exacerbated by other types of construction debris. An increase in the frequency of overbank flows is the most common consequence of flow obstruction. These may inflict water and sediment damage on adjacent property and structures.

Damage to Artificial Structures

The long-term changes in scour and fill processes which may accompany short-term sedimentation effects can lead to the failure of such structures as bridges and culverts, while nearby structures may be endangered by bank failures.

Impaired Recreational Use

Both short-term and long-term effects have the potential to disrupt downstream recreation. Direct use of a water body for activities such as swimming will be curtailed by short-term increases in suspended sediment levels or other aesthetic parameters which result in an unpleasant appearance. Indirect uses, such as stream bank parks and trails, will suffer from such long-term effects as the loss of aesthetic value due to bank failures, and unsightly erosion and sediment control measures (e.g. concrete channel, gabion baskets).

Contaminant Accumulation

Most contaminants of a persistent nature (metals, nonpolar organics) tend to accumulate in sediments over time. Introduction of sediments can lead to additional accumulation of contaminated sediments through:

- provision of additional surfaces for contaminants to adhere to; or
- introduction of contaminated sediment, e.g., many urban rivers carry significant sediment loads that can result in dredging problems at their mouths as well as flood control problems.

3 STREAM CHANNEL MODIFICATION

During the early stages in the formation of a stream, the force of water erodes the channel until a 'stable' configuration is established. This configuration is determined by the velocity and quantity (i.e. discharge) of water. In other words, a stable channel configuration is achieved when water flowing within a stream establishes equilibrium with the channel. However, since a stream is constantly changing it never really reaches a point where it stabilizes over the long term, but rather, a form of dynamic equilibrium is reached.

Flow in a stream channel varies from bank to bank. Only where a straight channel exists does flow on one bank approximate that on the other bank. On meanders, water at the outer curve of the meander is

generally travelling faster than on the inner curve. Thus, the erosional forces are much higher on the outer curve and material is picked up. On the inner curve, the velocity is lower and material is deposited. Over time, as the outer curve cuts deeper into the bank, the course of the stream changes. Stream channel meander, therefore, is a natural part of the evolution of a stream.

3.1 Purpose and Description

In urbanized areas natural channel movement is often undesirable. Stream channel wandering can jeopardize property and efforts are often undertaken to control the course of the stream, either to control its wandering within the existing banks, or to alter the channel course so as to accommodate the needs of the population. Stream channel modification may also be undertaken where changes in land use (i.e., reduced infiltration, rapid runoff) have necessitated flood control measures. This may involve deepening and/or widening the stream channel to increase streamflow (i.e. providing flood relief by rapidly channelling the water away), and/or straightening the channel. The proponent of a project involving instream/shoreline work should be aware that any in-stream activities will require a permit from the Ministry of Natural Resources.

Measures to increase streamflow may also require corresponding measures to protect/stabilize the banks. These may include the use of gabions, revetment walls, the placement of rip-rap and in some cases, the paving of sections of the stream.

In nearly all cases where stream channel modification is undertaken, it should be noted that alterations to one section/ part of the stream will normally trigger changes in other reaches of the stream, which may then have to be addressed as well.

Most channel modification is undertaken as part of flood control measures where the primary aim is to increase the runoff capacity of the channel to permit the rapid removal of storm water or snowmelt. In most cases the need to effect changes to a watercourse to accommodate changes in runoff patterns would be a consequence of poor land development/ construction practices. This problem can best be addressed in the planning stages of a project, primarily by ensuring that the development is planned such that large increases in stormwater runoff will not occur. In some cases it will be necessary to correct for past mistakes.

All channel modifications designed to increase runoff capacity will inevitably lead to increased erosion of the stream bed and banks until a new stable configuration is reached.

Channel modifications may also be undertaken to protect adjacent shorelands from erosion. Areas needing protection can include sharp bends in a watercourse, constrictions around bridges, and opposite banks where one stream (or an inflow) enters another. Structures used for bank protection usually provide blanket cover for the bank through the use of rocks or cement slabs, concrete mattresses, grout-filled bags, etc.

In most cases, stream channel modifications are the result of poor development practices, many of which were widespread in the past. Based on our current knowledge and experience these problems should no longer detract from the positive aspects of development and can best be addressed during the planning stage of the development. For example, the use of buffer strips and retention of bankside vegetation, as well as construction of swales, detention basins, and other such structures in new developments could eliminate the need for stream alteration in many cases.

However, it is recognized that such activities will be necessary in some cases to correct for past problems. Stream channel modification should only be undertaken after extensive review has determined that other, less intrusive methods are not feasible. In such cases the modifications should result in as natural a stream as possible. Where stream channel modification is undertaken, any of a number of changes to the stream can result:

a) Increasing Channel depth. - this is undertaken to increase the stream runoff capacity. Deepening of the channel will usually result in increased erosion upstream and increased deposition downstream, until the stream re-establishes a stable gradient.

b) Stream Widening. - also undertaken to increase stream runoff capacity. Disturbance of stream bank (riparian) vegetation may

result in further slumping of the streambanks and formation of migrating berms within the channel.

c) Channel Straightening (Diversion) - also undertaken to increase runoff capacity and for protection of streambank property. This may involve complete relocation of sections of the stream channel. Straightening the channel will often increase the bed and bank erosion, with subsequent deposition downstream. This can lead to the need for dredging at river mouths.

d) Structural Modifications - these include stream bank stabilization measures such as revetments, rip-rap, retaining walls, gabions or sheetpile. These are installed to maintain the form of the channel through reduction in streambank erosion.

Note: The Ministry of Natural Resources has prepared a guide to the construction of natural channels. The proponent should contact the local MNR office early in the planning stage to ensure that all requirements are met.

General Provisions for Work In or Near Watercourses

1) Construction activity should be confined to designated work areas (includes access roads, maintenance areas, parking areas and haul routes). Areas on which no work is designated should be protected with suitable barricades.

2) A spills containment kit for petro-chemical fuels and any other potentially deleterious substances should be on site and immediately available, and all employees should be trained in the proper spills cleanup procedure. The kit should consist of, at the least, sufficient absorbent boom and swabbing material to initially contain a spill as well as protective gear for handling of hazardous chemicals.

3) Clearing, grubbing and topsoil stripping should only be performed immediately prior to commencing work in those areas. Work areas should be stabilized as soon as possible after work has been completed.

4) Drainage ditches and other watercourses for surface water drainage should be properly maintained during construction, incorporating appropriate sediment retention measures.

5) Equipment maintenance (fuelling, cleaning, etc) should be done in designated areas. No re-fuelling should take place closer than 5 meters from the watercourse. Equipment (including empty fuel or other containers) cannot be cleaned in the watercourse. Excess fuels, lubricants, pesticides and other supplies should be removed from the site and disposed of in an approved manner.

6) In-stream construction should not interfere with fish migration and any such work will require prior approval from the Ministry of Natural Resources.

3.2 Recommendations for Channel Straightening (Diversion)

Inevitably, channel diversion will result in a period of increased turbidity within the new stream channel until a stable configuration is reached. Therefore, such modifications should only be undertaken where no feasible alternative exists.

a) All channel straightening should be undertaken using 'dry' construction techniques.

b) All necessary bank stabilization should be completed before water is diverted to the new channel.

c) Adjacent vegetation should be preserved to help stabilize the banks.

3.2 Recommendations for structural modifications:

a) The area should be properly aligned and graded to stable slopes and well compacted.

b) The proposed structure should be designed to withstand the pressures of flow and be safe against damage by ice, floating debris and frost action.

c) The structure should be sufficiently tight to

prevent leaching of the underlying soil materials.

d) The structure should be flexible enough to conform to irregularities in the bank and later settling of the foundation.

e) The structure should be permanent, i.e., the structure should be built as a permanent solution to the problem it was designed to solve.

f) Work should be done during low flow periods and in some instances work may require use of cofferdams. Operations in recreational areas should be timed so as to not unduly interfere with recreational uses.

g) No cement or lime should be allowed to enter the watercourse.

h) Construction debris should be collected and disposed of in an approved site.

i) The ends of the structure should be secured within stable areas adjacent to the area to be protected.

j) Adequate toe protection beyond the anticipated scour line should be provided.

4. SWAMPS AND WETLANDS

Construction related activities in swamps and wetlands pose special problems and concerns. In addition to the large habitat diversity provided by wetlands, they also serve as an important means of water treatment and flood control.

The ability of natural wetlands to remove sediment serves to provide effective water treatment. Since there is no appreciable current in wetlands, sediments drop out, and wetlands are thus able to absorb and store a great deal of nutrients. However, for this reason wetlands can also accumulate significant levels of contaminants as these accumulate in sediments as well. Thus, wetlands cannot be considered as a substitute for effective source control of chemical contaminants.

Wetlands are extremely sensitive to alterations such as channelization, dredging, filling and sedimentation. Sedimentation can obstruct the biological processes by destroying habitat and reducing primary production. These areas should be left intact wherever possible.

Typical construction activities that could affect wetlands would be road and transmission line crossings (pipelines, electric power), urban development and agriculture and marinas.

In addition to these concerns, the routing of urban storm runoff water to wetlands, or the use of wetlands as an alternative to treatment can lead to the accumulation of contaminants. The use of constructed wetlands for stormwater treatment is addressed in the Ministry document "Constructed Wetlands for Stormwater Management" (April 1992).

The proponent should be aware that a proposed activity in or adjacent to a wetland must be consistent with the Provincial Wetlands Policy issued under Section 3 of the Planning Act. In Provincially Significant Wetlands or other classified wetlands most activities will require prior approval from the Ministry of Natural Resources. Many construction activities will be prohibited in such areas.

Where road and transmission line crossings are unavoidable, care should be taken to:

a) provide adequate cross drainage for road construction to ensure exchange of water

b) limit the disturbance of natural vegetation for pipeline and transmission line crossings

c) install proper sediment control structures where construction activities are taking place upstream of the wetland to prevent deposition of excess amounts of sediment in wetlands.

d) limit any construction in or through the wetland to the low-water period.

Urban development and agricultural development should avoid wetlands entirely. Both, if properly planned, could take advantage of the natural water quality enhancement potential of a wetland for treatment of runoff. The use of wetlands for the

creation of marinas and boat basins should also be discouraged, since the dredging involved in these activities will permanently disturb a wetland.

5. URBAN DEVELOPMENT

Urban development refers to construction of housing units, subdivision development, industrial development, and waterfront development.

Activities associated with urban development include a variety of operations such as: clearing; topsoil stripping; excavation; access construction; backfilling, and; site remediation.

Erosion and sediment control measures on urban construction sites typically fall into one of two categories. They are either designed for temporary use during the construction period, or they are designed as permanent stormwater management structures. Clearly, since erosion and sediment control concerns do not end upon completion of construction, incorporation of long-term stormwater management facilities into the original design would be the most effective. Where long-term facilities have been included in the original site development plan, construction of such facilities should be one of the first priorities.

Detailed discussion of methods and implementation procedures for sediment and erosion control on urban development sites is available in the Ministry handbook " Guidelines on Erosion and Sediment Control for Urban Construction Sites". Additional information is available in the report "Erosion and Sediment Control Practices Study Technical Report" by the Ministry of Environment and Energy and the Metropolitan Toronto and Region Conservation Authority. Reference should also be made to the MNR publication "Fish Habitat Protection Guidelines for Developing Areas" published in 1994.

5.1. Potential Impacts

Large scale urban construction projects involve a variety of unit operations which must be evaluated independently, although it must be remembered that the effects produced from the project as a whole are greater than the sum of the individual unit operations. Thus, for example, while evaluation must take into account the effects of sediments produced from cuts and fills on the aquatic environment, consideration has to be given to the combined (synergistic) effects of sediments, possible oil spills from construction machinery, toxicity of construction related chemicals, etc. The major problems encountered in urban development are those of erosion and sedimentation resulting from mass grading, which leaves large areas of bare soil exposed for considerable lengths of time, as well as from unprotected cuts and fills, and stream fording.

Other impacts that can be mitigated by proper planning and design include reduction of infiltration and increased surface runoff.

Construction effects:

a) mud tracking from construction sites onto adjacent municipal streets;

b) silt and debris being washed into the existing sewer system;

c) silt and debris being carried into receiving watercourses by rain and surface flows and through the sewer system;

d) wind blown dust during dry summer months; and

e) spills of petro-chemicals (fuels, lubricants) for operation of heavy equipment.

5.2 Evaluation

A number of Municipalities have or are developing By-laws to control sediment and erosion from urban construction sites, principally through permits for the removal of topsoil. The Municipality should be consulted prior to the commencement of any work to ensure the proper permits have been obtained.

Most such By-laws require the submission of a comprehensive erosion control plan, which will often include:

(1) a key map showing the location of the site;

(2) the site boundaries and number of hectares of the site;
(3) the use of the land and the location and use of the buildings and other structures adjacent to the site;
(4) the location, dimensions and use of the buildings and other structures existing or proposed to be erected on the site;
(5) the location of lakes, streams, wetlands, channels, ditches, other water courses and other bodies of water on and within thirty (30) metres beyond the site boundary; NOTE: In the case of a provincially significant wetland a 120 m buffer strip may be required.
(6) the Regional Storm Flood Plain and Conservation Authority Fill Regulation lines;
(7) the location of the predominant soil types;
(8) the location and type of vegetative cover;
(9) the location and dimensions of any existing and proposed storm water drainage systems and natural drainage patterns on and within thirty (30) metres beyond the site boundary;
(10) the location and dimensions of utilities, structures, roads, highways and paving;
(11) the existing site topography at a contour interval not to exceed one half of one metre and to extend a minimum of thirty (30) metres beyond the site boundary;
(12) the proposed final elevations of the site;
(13) the location and dimensions of all proposed land disturbing activities;
(14) the location and dimensions of all temporary soil or dirt stockpiles;
(15) the location, dimensions, design details and design calculations of all construction site control measures necessary to meet the requirements of this By-law;
(16) a schedule of the anticipated starting and completion dates of each land disturbing or land developing activity, including the installation of construction site control measures needed to meet the requirements of this By-law;
(17) provisions for the maintenance of the construction site control measures during construction;
(18) the scale of drawing; and
(19) any other necessary information with respect to the site.

(The above has been excerpted from the Mississauga Topsoil By-law, which is a typical example of such By-laws).

In addition to the above, the following recommendations should be followed:

a) Construction procedures and sequence should be planned so that work that could lead to severe erosion is carried out during dry weather. Such measures would be in addition to those described as part of the erosion control plan submitted by the developer.

b) In areas where the project abuts a watercourse, a buffer strip of 30 metres should be left undisturbed between the project and the watercourse.

NOTE: The MOEE/MNR publication "Interim Stormwater Quality Control Guidelines For New Development" (May 1991) requires that a minimum of 15m buffer strip be maintained for streams with warmwater fisheries and a minimum 30m buffer strip be maintained for streams with coldwater fisheries.

c) Access roads to the site should be clearly defined and have all-weather surfaces. Use of heavy construction machinery should be restricted to the inner perimeter of the site. Efforts should be made to site access roads for permanent use.

d) Interim sanitary waste collection and treatment facilities must be provided during the construction period. All trash must be collected and disposed of at an approved site.

e) On-site machinery maintenance, including cleaning of cement trucks, must be done in specially designated areas provided with facilities to retain soils, solids, etc. These wastewaters must be adequately treated prior to disposal. The contractor should have on site a spills containment kit consisting of, at the least, sufficient absorbent boom and swabbing material to initially contain a spill as well as protective gear for handling of hazardous chemicals.

f) Use of herbicides, pesticides, defoliants, etc. requires proper permits and licenses.

5.3 Development of an Erosion and Sediment Control Plan

Stormwater runoff is the most serious erosion concern at most development sites. The flow of stormwater over unprotected/ exposed soil has high erosion potential and a single storm can result in the loss of considerable sediment to nearby watercourses. The susceptibility of a site to erosion depends on three site characteristics:

1) the site surface slope gradients. Steep slopes that result in an increased runoff velocity are capable of removing and transporting a greater sediment load.

2) the length of the slopes. Long slopes are more prone to erosion than short slopes.

3) soil erodibility, which is based on:
   a) soil drainage/ infiltration
   b) soil texture

The method for determining the soil erosion potential is described in the MOEE publication "Guidelines on Erosion and Sediment Control for Urban Construction Sites, May 1987".

Soil erosion within the site during construction is recognized as an unavoidable part of site development. However, a control plan must be instituted to ensure that sediment is not transported off-site, or does not reach watercourses. In developing an erosion control plan, the proponent should choose the most appropriate measures for the site.

The traditional approach to storm water management has been to channel all storm runoff water to storm sewers and hence to receiving watercourses. This can contribute to the loading of pollutants from street runoff, as well as instream erosion. Methods for managing storm water on-site should be considered as alternatives. Many of the techniques available can be incorporated into the design of the development for long-term use. Many of these techniques have also been found to be effective in removal of contaminants such as trace metals.

Methods that detain water to allow increased infiltration or settling of suspended materials include:

• detention ponds ("dry" or "wet") to detain runoff.

• extended detention basins to detain water and increase settling of particles

• infiltration basins to impound water over permeable soils to increase infiltration.

• infiltration trench to increase infiltration
• wetland treatment - similar to detention ponds.

• vegetative filter strips to slow runoff and trap particulate material

• vegetated swales to promote infiltration and trap particulates

All of these options will require some periodic maintenance. Those that detain water over a porous material in order to enhance infiltration will experience a reduction in efficiency as pores become clogged. Without regular maintenance, the useful life-span of these structures could be considerably reduced. Detention ponds require periodic dredging to remove accumulated sediment in order to maintain proper capacity and are not maintenance-free options. The accumulation of contaminants in sediment from urban runoff can restrict the disposal options for this material.

In addition, the proponent should contact the local municipality to ensure there are no specific requirements and to ensure acceptability of the erosion control plan and compliance with local by-laws.

Planning and Design Considerations

A number of measures can be used to mitigate the effects of urban development simply through careful planning and design. The original development plan should consider such things as:

• limiting development and construction to least critical areas. (i.e., avoid shorelines, floodplains, natural drainageways, steep slopes, erodible soils and porous soils).

• all efforts should be made to preserve and utilize natural drainage systems. Designs should minimize impermeable surfaces (driveways, sidewalks, road widths) with the intent of maximizing infiltration.

• consider alternative methods of runoff and stormwater management that enhance infiltration. This can have added benefits in maintaining normal stream runoff and alleviating the need for additional stream alteration (channelization, revetments, etc).

5.4 Temporary or Construction Phase

Sediment and erosion control methods are typically divided into two groups: those employed only during the construction phase, termed temporary measures, and those incorporated into the design of the development and intended for permanent use.

Sediment and Erosion Control Methods

1) Stockpiles should be located away from watercourses and stabilized against erosion as soon as possible.

2) Vehicles should leave a construction site at a designated point or points provided with a bed of non-erodible material of sufficient length to ensure that a minimum of material (mud) is tracked off the site onto adjacent municipal streets. In addition in certain areas additional measures such as a high pressure pump and hose installation may be necessary to remove excessive amounts of dirt embedded in the tires or tracks of large vehicles.

3) When sewers have been installed and work is either suspended on the site for a period (i.e. winter), or house construction is in progress measures must be undertaken to ensure that sediment and debris do not get into the municipal sewer system.

   • the manholes and catch basins should be sealed (i.e. by installing plates under the covers) and a temporary drainage system should be used with appropriate velocity controls (e.g. strawbales, retarding fences) and temporary storage areas for sediment control. Care should be taken to ensure that the temporary drainage system does not flood adjacent properties.

   • other methods of catch basin inlet protection, such as filter fences, geotextile fabric and gravel, concrete block and gravel, or an excavated sediment trap surrounding the catchbasin may be used. Appropriate use of these should be decided on a case-by-case basis.

4) Where on-site or downstream detention facilities are provided, use can be made of quantity control facilities for sediment control during construction. Therefore, all temporary and permanent detention facilities should be constructed prior to the installation of any services on the site or the commencement of earth moving operations. Similarly, any retention facility which will act as a sedimentation pond should be constructed prior to the installation of any other services on the site or the commencement of earth moving operations.

5) Upon completion of the work, all accumulated sediment, debris and work related material should be removed and properly disposed of.

Erosion Control Measures

An effective erosion and sediment control strategy is directed towards preventing the production of sediment through application of on-site erosion control measures. This is achieved through:

(a) the protection of exposed surfaces, and
(b) the control of runoff.

It should be emphasized that the movement of eroded material within a site by stormwater is not necessarily a concern. However, there is a concern when sediment-laden flow leaves a site.

Protection of Exposed Surfaces

The protection of exposed surfaces from erosive forces is the primary goal in the selection of appropriate control measures. This is commonly achieved through the use of temporary or permanent vegetative cover, mulching, paving, and chemical stabilization.

SEDIMENT CONTROL MEASURES

While the prevention of the initial erosion process should be the primary goal of all sediment control measures, the production of some sediment on construction sites cannot be entirely eliminated. In most cases, the erosion control measures selected should be complemented with some form of sediment retention in order to prevent off-site sedimentation damage. Generally this can be achieved by: (a) filtering the sediment-laden flow, or (b) impounding the sediment-laden flow, to allow the settling out of the sediment particles.

Filtering

Filtering involves the use of natural and artificial filter materials (vegetative strips, stone filters and man-made fibre filters etc.) to remove sediment from runoff water. They can effectively be applied to concentrated channel flow at the inlets of permanent or temporary drainage systems. Since the filter material can rapidly become clogged during periods of sustained high flow, this application requires careful maintenance to ensure continued effectiveness.

Filtering is most effective when sheet flows from a wide area are filtered along a line adjacent to the entrance to a drainage system (e.g., stream banks) or at the toe of the slope of an embankment.

The most commonly used filtering methods are straw bales or silt curtains. Both are intended for filtering of sheet or overland runoff and are usually useful only where small amounts of runoff are involved.

Straw bales:

- moderately effective for trapping medium and coarse grained particles
- generally ineffective for trapping fine-grained particles
- improper installation can increase erosion by concentrating runoff.

Silt Curtains/Fences:

- are effective for trapping all particle sizes, depending on the mesh size used.
- are designed primarily for overland flow and are ineffective in areas of concentrated flow

5.5 Control of Runoff

Commonly used methods for the protection of ground which must remain exposed include the modification of slope surface, the reduction of slope gradient, the control of velocity of flow, the diversion of flow around the affected area, and the upstream storage of potential runoff. The measures described should form part of the sediment and erosion control plan for the construction phase, and should also be incorporated into the design of the project, since many of these measures can be incorporated into the long-tern plans for the development.

Reduction of Slope Gradient

This involves careful grading of the land surface to decrease slope and direct runoff to a stable outlet.

Reduction of Flow Velocity

Reducing slope gradient and the length of slope, as well as using vegetative or other surface cover to reduce flow can result in a considerable reduction in the erosive potential.

Diversion

Where slope gradient or length cannot be reduced the creation of channels, usually across a slope to intercept and divert runoff to stable outlets, can reduce erosive potential. These channels can be temporary (for use solely during the construction period) or incorporated into the design of the development and thus part of the overall storm-water runoff design (i.e., ditches and other conveyance

channels). Any diversion channel should be stabilized, such as lining with cobble, vegetation, etc. in order to prevent erosion of the diversion channel. Use of diversion channels will not eliminate the need for other preventive or control measures, such as filtering or impoundment, especially for temporary diversions. Diversions should therefore be considered as part of a larger erosion control system incorporating sediment traps and settling ponds.

Impoundment

The impoundment of sediment laden flow in sediment traps permits the settling of suspended sediment particles. This technique is normally applied to concentrated flow within the permanent or temporary drainage system of a site.

Traps may be formed through excavation, above ground embankments, or a combination of the two, and are commonly constructed of earth and/or stone, and may additionally involve the use of strawbales. Correctly constructed and well maintained sediment traps can be an effective means of minimizing the quantity of sediment which is transported away from the construction site.

Ideally, the sediment trap should be located within the site near the sediment source. Only the area exposed to erosion should drain into the trap. Roadside ditches and old drainage channels could also be used as sediment entrapment areas.

Depending on the runoff and available storage, temporary impoundment areas can be designed to store the entire runoff (and sediment) from the selected design event, or discharge the flow after most of the sediment entering the facility has been deposited.

Temporary impounding areas that are created by the construction of significant embankments must be designed by a qualified and experienced engineer. Requirements for inspection of the facility during and after construction should also be stipulated. Similarly, the optimization of pond area and depth by a qualified engineer can provide maximum efficiency at least cost.

5.6 Permanent Stormwater Runoff Control

A number of structures are available for incorporation into the site development plans for long-term control of runoff water. Unlike the methods so far described, these structures would not be removed upon completion of construction but would form part of the completed development and would serve as a component of the site stormwater runoff plan. Most of these structures are effective primarily in residential areas, and have been shown to be relatively ineffective in highly developed urban areas. All of these structures would require integration into a proper urban design. Their failure in the past has most often been due to their having been designed to meet only the minimum hydraulic criteria, without regard for the urban community or the natural environment (Ferguson, 1991).

A detailed discussion of these is available in the Ministry of the Environment publication: "Stormwater Quality Best Management Practices" June 1991.

Detention Ponds

Known variously as retention ponds and wet ponds, these are permanent waterbodies that have built-in capacity to accept additional runoff water. The ponds drain through pipes which allow excess water to drain slowly. They can be effective for both reduction of downstream erosion and the trapping of sediment and contaminants. A number of variations on the basic design are available and such ponds can range from relatively small single basins to multiple basin systems comprised of a number of interconnected basins and associated wetlands.

Due to accumulation of sediment, these structures require regular maintenance to ensure that proper capacity and adequate drainage are maintained. Depending on the local drainage area, disposal of these sediments may require special arrangements due to contaminant accumulation.

Extended Detention Basins

These detain runoff water for a fixed period of time, allowing the water to drain slowly through a fixed opening. The detention of water allows particulates to settle out and, through detention and

slow release of runoff, can help to prevent downstream erosion. The basins are generally designed to be dry between runoff events. However, clogging appears to be a major concern, with the result that many such basins can become standing water habitats if not properly maintained. Nuisance insects and plants can then become a problem. They have not been found to be highly effective in removing nutrients or contaminants, though all seem to effect at least some removal.

Infiltration Basins and Trenches

These are impoundments created to detain water for the purpose of enhancing infiltration. The basins are usually dry, often with a densely grassed bottom and have only emergency spillways/drains. While the ability of these basins to trap sediment and contaminants is high, the ponds tend to be relatively short-lived. Rapid clogging can significantly reduce infiltration. These ponds require high maintenance, particularly where runoff water is high in particulate matter.

Grassed Swales

These are earthen conveyance channels, which, unlike conventional gutters, can enhance removal of sediment and pollutants and increase infiltration. With proper maintenance (removal of accumulated sediment), they can last indefinitely. Efficiency of pollutant removal depends on design of the system. Designs that incorporate features such as check-dams that increase detention time are usually more effective in removing sediment and contaminants.

Filter Strips

Filter strips refers to vegetated strips of land between the development site and the watercourse. They are designed to accept runoff only as overland flow, and generally incorporate some feature such as stone trenches to prevent channelization of flow. In order to be effective, they must be relatively level. They can effectively reduce sediment and pollutants from entering the watercourse if they are properly maintained (sediment removal, re-grading, repair). Through maintenance of stream bank riparian vegetation they can help maintain the natural character of the watercourse (i.e., fisheries potential).

Wetland Treatment

These are constructed wetlands and do not entail the use or modification of natural wetlands for treatment purposes. They consist of shallow pools that provide suitable growing conditions for marsh plants. Sediment and pollutant removal is effected through uptake, retention and settling. These systems require periodic maintenance to establish the wetland and remove accumulated sediment. They could pose a concern due to accumulation of contaminants and their potential uptake by resident plants and animals. Additional details are provided in the MOEE document "Constructed Wetlands for Stormwater Management" (April 1992).

6. WATERFRONT DEVELOPMENT

This section refers to construction activities associated with commercial or private development related to water-based recreation. Such activities may include dock/boat house construction, seasonal or permanent residences, shoreline protection, beach creation, dredging for boat channels, filling of shorelands, etc. Marine construction projects are dealt with extensively in the following section (Section 7) and this should be consulted prior to commencing any work. Many of the sediment protection measures described in Section 5 are also applicable to construction of seasonal and permanent residences on waterfront properties.

In addition to the guidelines developed by MOEE, a number of Acts apply to these types of projects and are summarized below (excerpted from MNR brochure "Working Around Water - what you should know" MNR 1991):

> The Public Lands Act: provides that no person shall dredge or fill a shoreland or work on any public land without a work permit.
>
> The Lakes and Rivers Improvement Act: provides that any work forwarding, holding back or diverting water must receive prior approval of the

Ministry of Natural Resources.

The Canada Fisheries Act: administered by the Ministry of Natural Resources, provides that no person shall carry on any work that results in the harmful alteration, disruption or destruction of fish habitat without authorization. The Act also provides that no person shall deposit a harmful substance of any type in water frequented by fish.

Proponents are strongly advised to consult the local MNR offices before any work is undertaken, to ensure the project is acceptable and that the appropriate permits can be obtained.

In addition to these requirements, certain types of activities, such as dredging and shoreline filling, are also reviewed for potential impacts on water quality by the local Ministry of the Environment and Energy office. Dredging proponents should refer to the MOEE publication "Evaluating Construction Activities Impacting on Water Resources Part III: Handbook for Dredging and Dredged Material Disposal in Ontario" (February 1994)

6.1 Nearshore Construction

Nearshore work typically involves the construction of seasonal or permanent residences, or other structures where land disturbing activities may be necessary (e.g., septic system installation).

a) Buffer strips should be maintained to minimize loss of material to adjacent waterbodies.

b) Site preparation (stripping of ground cover and excavation) should not be undertaken until construction is ready to begin. The area disturbed should be kept to a minimum.

c) Erosion and sediment control measures (see Section 5) should be used to minimize loss of material to the waterbody.

6.2 Shoreline Construction and Stabilization

Shoreline construction refers to activities taking place directly adjacent to, or in, the waterbody.

In addition to a Work Permit from the Ministry of Natural Resources, the following considerations will assist proponents in planning and conducting an environmentally sound project:

a) work should not be conducted during the peak recreational season if such work will unduly interfere with recreation.

b) activities in critical habitats such as fish habitat must be approved by MNR prior to commencing any work.

c) work must not result in water quality impairment that would affect nearby water uses.

d) equipment, methods and procedures must be selected so as to minimize turbidity during dredging or filling operations.

e) once commenced, the project must be completed as soon as possible. Any shore areas that have been disturbed should be stabilized and revegetated as soon as possible upon completion.

f) surplus material must be adequately deposited at pre-approved sites or put to proper reuse. Placement of excess material must be above the high water mark (i.e., so that the material will not regain access to the water)and should be stabilized as soon as possible to prevent erosion.

g) all debris must be contained in the immediate work area and adequately disposed of on land.

h) gravel and sand to be placed in a lake or river should be clean and free from fine materials and organic matter.

6.3 Use of Pesticides and Wood Preservatives

Vegetation Control

Aquatic plant control along shorelines or in the water will require the approval of the Ministry of Natural Resources, since these areas are usually considered as important fish habitat. In addition, proposed chemical control will also require a permit and/or license from the Ministry of Environment and Energy under the Pesticides Act. In most cases chemical control is not recommended for small scale

projects.

Wood Preservatives

If wood is to be treated with oil, creosote or some other chemical, the treatment should be undertaken some time in advance of placing the material in the water. A number of wood preservatives are available to the property owner: pentachlorophenol (PCP); creosote (CRT); copper or zinc naphthanate (CNP or ZNP); copper-8-quinolinolate (Cu-8); tributyltin oxide (TBO); dichlofluanid (DCO); and, disodium octaborate tetrahydrate (Tetra borate). Of these, only PCP and creosote are registered for use on wood that will be submerged, with the remainder registered for above ground use. Label directions should always be followed. In addition, when using these products to protect wood surfaces that contact water, the precautions listed below must be followed in order to minimize any losses of potential contaminants to the water.

- application of preservatives to wood should not be carried out near or above water.
- if wood from an existing dock or other structure is to be treated, then it must be removed from water prior to treatment and allowed to dry thoroughly before replacing.
- after drying is completed, all treated surfaces should be scrubbed and wiped to reduce residual oils before placement in water.
- clean application equipment (i.e., paint brushes, sprayers, etc.) and discard waste safely and away from water.

Wood treated with a preservative requires the following drying time: PCP - 12 days; CRT - 6 months; CNP or ZNP - 7 days. Creosote (CRT) requires a long drying time and it should not be applied to any surface where body contact is expected. Creosote-treated wood should not be placed close to drinking water intakes.

Pressure-treated wood containing chromated copper arsenate (CCA) is a popular construction material that can be purchased from building suppliers. This material is sold ready-dried, though in practice drying and weathering times can be highly variable, depending on how long the suppliers and manufacturer have stored the material prior to final sale. CCA treated wood should not be cut over water.

Note: It is recommended that care be taken to ensure adequate personal protection during the use of chemical preservatives.

A fact sheet on using treated wood is available from most MOEE local offices.

The Ministry of Natural Resources has produced a series of fact sheets entitled "Working Around Water" that discuss preferred methods of waterfront development such as construction of docks, boathouses, etc. These are available to proponents from their local Ministry of Natural Resources offices and should be referred to prior to commencing any project. In addition, the proponent must have applied for and received any necessary permits before commencing any work.

7. MARINE CONSTRUCTION PROJECTS

These include construction of shoreline stabilization structures, shoreline dredged material disposal facilities, harbours and marinas, lakefills, piers, water intakes, wastewater outfalls, offshore drilling, and underwater blasting. The construction of water and sewer supply systems is considered as part of urban development and is covered in those sections.

All marine construction projects will require approval by federal and /or provincial agencies such as Canada Department of Fisheries and Oceans (DFO), MNR, MOEE. The proponent is responsible for ensuring that all necessary approval have been obtained prior to commencing any work.

The Ontario Ministry of Natural Resources has prepared a number of documents to ensure that fish and fish habitat are protected during marine construction. The local MNR office should be contacted for additional information and guidance.

7.1 Shoreline Stabilization Projects

Shoreline stabilization and protection projects are undertaken to protect valuable land or installations from erosion resulting from wave action or inundation during high lake levels. This is usually achieved through structural measures that protect against forces generated by wind and water. On the Great Lakes, the major concern to shoreline stability is the threat posed by wind generated waves, which is often compounded in areas of high bluffs with instability due to groundwater seepage.

Natural shorelines are dynamic in that they continually readjust to accommodate different water levels, the changing direction of incident waves, changes in soil characteristics of the shoreline itself, and modifications to adjacent shorelines. In the nearshore zone of the Great Lakes, wave energy moves littoral material (supplied by beaches, bluffs and tributaries) in a longshore direction. Often there is a net littoral drift in a given direction as a result of the prevailing current from that particular direction.

The littoral drift helps maintain beaches by setting up a dynamic equilibrium in material moving in and out of an area. If this process is impeded through the construction of coastal protection measures, the established regime will change and littoral drift material will accumulate updrift of the protective barrier and, consequently, downdrift beaches, starved of littoral material, may start eroding. Therefore, it becomes extremely difficult to protect a small part of a shoreline without adversely affecting adjacent areas.

Since littoral drift is the direct result of wave energy against the shoreline, most shore protection measures designed to reduce the incident wave energy or isolate the shoreline from that energy (or both) will necessarily have some effect on littoral drift.

Significant effects can result from the cumulative effects of shoreline alteration. The design and planning stage should carefully consider how the proposed work may affect existing and planned shoreline works.

The actual construction of most common shore protection measures described in this section has little direct impact on water quality. Materials placed in water (steel piles, precast concrete, rock and timber) are, by design, durable and inert. Some localized erosion may result from providing access to the work site, particularly in bluff areas. Appropriate silt and sediment control devices may be required in some areas, both in the water and on adjacent land.

More important water quality changes will result from the effect of stabilization of the shoreline. In areas where fine grained soils had been eroding, a net improvement in water quality may result if downdrift erosion has not been enhanced.

Downdrift erosion is the most common problem associated with shore protection installations. Water quality deterioration can be severe in instances where protective beaches are destroyed and bank erosion commences.

The littoral zone is the most biologically productive zone of a lake. The numbers of taxa and the relative density of fauna are directly proportional to the stability of the substrate. Areas characterized by high rates of erosion will have sparser communities than stable shorelines, although they may be locally important. Wave action and currents are necessary to prevent siltation of coarse substrate fish spawning areas.

Proponents of shoreline stabilization projects should be aware that such projects require, at a minimum, the prior approval of the Ministry of Natural Resources, and can proceed only upon receipt of a Work Permit issued by that Ministry. MNR should also be contacted regarding specific technical details of the project.

Description

Shoreline stabilization structures include bulkheads, revetment walls, groynes and breakwaters.

a. Bulkheads

Bulkheads are vertical or near-vertical structural walls designed primarily to retain fill. They do provide some protection against waves, primarily through reflection of waves rather than dissipation of wave energy. As such their ability to withstand wave action over the long-term is poor.

Bulkheads can be constructed of a variety of materials such as timber, concrete, masonry, or steel

sheet pile.

Since bulkheads effectively isolate the backfill material from the water, the quality of the material used need only meet the conditions for backfill as described in the MOEE document "Guidelines for Management of Soil, Rock and Like Material" (in preparation). Materials used behind impermeable barriers on the shore are not subject to the Lakefill Quality Guidelines.

Recommendations for Bulkhead construction.

a) Construction should be carried out during the low water, calm period.

b) The structure should be designed against failure, which could result in water quality effects where contaminated backfill has been used.

c) The design should minimize off-site impacts, particularly downdrift erosion. The size of the area should be kept as small as possible. Construction equipment should operate only from the shore and should be kept out of the water.

d) The design plan should include regular inspection and maintenance.

b) Revetments

Revetments are sloping protective facings (commonly of rip-rap, concrete slabs or gabion baskets) designed to protect the underlying bank from erosion. Due to the low slope, they generally dissipate wave energy better than bulkheads.

Recommendations for Revetment Construction

a) All construction should be carried out during low water, calm periods to minimize turbidity effects due to loss of sediment.

b) Minimize off-site impacts in relation to erosion or deposition of material in previously unaffected areas, through careful design.

c) Installation should be backed by gravel or filter cloth to minimize washout and settling, while relieving pore water pressure.

d) Design plan should include regular monitoring and provision for periodic maintenance.

c) Groynes

Groynes are walls built lakeward from, and usually perpendicular to, the shoreline. Typically they are built of steel or timber piles, or stone, and may be permeable or impermeable. They are intended to deflect waves, littoral currents, and to capture littoral material to build or maintain a beach.

Material used in the construction of groynes which are directly in contact with water must meet the provisions of the MOEE "Fill Quality Guidelines for Lakefilling in Ontario".

Recommendations for Groyne construction.

a) All construction should be carried out during low water, calm periods to minimize turbidity effects due to loss of sediment.

b) The structure should be designed against failure, which could result in water quality effects. Only clean material should be used as backfill to minimize water quality impacts in the event of failure of the structure.

c) The design should minimize off-site impacts, particularly downdrift erosion. The size of the area should be kept as small as possible.

d) Breakwaters

Breakwaters are walls built to shelter a shoreline from wave action. They may be connected to the shoreline or placed offshore. Their expense is usually justified only when the sheltered water it creates is needed for a harbour. Recently, floating tire breakwaters have been deployed. Their use is not recommended. In addition to being effective only for short period waves, recent studies have indicated that the use of tires in water could result in localized toxic effects due to leaching of compounds from the tires.

Breakwaters should be constructed only of inert material resistant to erosion, such as quarry stone or concrete rubble. Both the core and the exterior of the breakwater should be constructed of such material.

The use of loose soil or soil-like fill material is not acceptable.

As with other permeable structures, the quality of the fill material used in the breakwater must meet the Fill Quality Guidelines for Lakefilling if material other than quarry stone or clean concrete rubble is used.

e) Artificial Headlands

While the best form of shore protection is an energy absorbing beach, most problems occur during high water levels which diminish the effectiveness of beaches to protect adjacent land areas from erosion. Protection can be enhanced by artificially raising the beach elevation with imported fill of the correct grain size (often dredged from offshore). Protection is most effective with use of a perched beach retained by a sill.

Natural shorelines that have long-term stability are usually comprised of curved beaches between non-erodible points of land. The beaches are oriented perpendicular to the net wave approach. The addition of armouring to lengthen and reinforce existing promontories, particularly at littoral drift nodal points, shows some promise as a shore protection measure. On a smaller scale, long shallow beaches can be subdivided into a series of shorter, more sharply curving beaches between artificial hardpoints to minimize littoral transport out of the system. The construction of large artificial hardpoints is discussed more fully in the section dealing with lakefilling (Section 7.3.1).

The quality of the fill material used in the construction of artificial headlands must meet the Fill Quality Guidelines for Lakefilling if material other than quarry stone or clean concrete rubble is used in contact with open water.

General Considerations

The proponent of any shoreline construction project should contact both the Ministry of Natural Resources and the Ministry of the Environment and Energy in order to obtain the necessary permits to carry out the project. To facilitate the process of project review the proponent should have available the following information.

- Identify shoreline type and geomorphology including stratigraphy of nearshore zone deposits.
- Describe on-shore and off-shore topography.
- Direction and characteristics of littoral drift.
- Historical information on erosion rates.
- Wind, wave and current climate at site on a monthly basis preferably covering a 20 year period.
- Water level frequency information under calm and storm conditions.
- Ground water information.
- Water quality characteristics.
- Aquatic habitat characteristics, including fish species information.
- Intakes in vicinity and surrounding land use.
- Design details of proposed structures, including design life maintenance requirements.
- Proposed land use modifications.
- Proposed method of construction and scheduling.
- Economic constraints.
- Anticipated off-site impacts.

The above list is provided only as a guide. Specific requirements will vary from site to site, depending on local conditions, and will be determined on a case-by-case basis by the appropriate MOEE and MNR offices.

7.2 Dredged Material Disposal Facilities

Concern about the water quality implications of open water disposal of contaminated dredged material has led to the construction of containment facilities throughout the province. Since the mid-1970's, the Ministry of the Environment and Energy has evaluated the quality of sediments for suitability for open water disposal using chemical, physical and

biological criteria.

- From 1976 onward, the suitability of dredged material for open water disposal has been evaluated according to the criteria laid out in the Open Water Disposal Guidelines.

- In June of 1992, these guidelines were superseded by the Provincial Sediment Quality Guidelines (PSQGs)(Persaud *et al.* 1992).

- All dredged material must pass the criteria as described in the PSQGs in order to qualify for open water disposal.

Details on dredging and dredged material disposal are described in a separate document: "Evaluating Construction Activities Impacting on Water Resources Part III: Guidelines for Dredging and Dredged Material Disposal".

Some disposal facilities have been constructed on land but many have been extended into the nearshore zone due to the difficulty and expense of acquiring upland sites. Confined Disposal Facilities (CDFs) have been built at many Great Lakes harbours, and are generally sized for long term use (5 to 10 years).

Typically, the disposal site is a one or two celled structure built within 1 km of the dredging area to facilitate disposal, particularly where the dredged material is pumped through a pipeline as a slurry (e.g., cutter suction hydraulic dredging). Where nearby sites have not been available, dyked areas within 5 km have been constructed for material transported in bottom dump scows.

While material disposed of in CDFs is not subject to the PSQGs, the construction of the perimeter walls is controlled under the Fill Quality Guidelines for Lakefilling. Depending on the level of contamination in the material to be contained, the structure must be so constructed that it is impermeable in order to retain contaminants. Construction of the perimeter walls must be through use of clean materials.

<u>Shoreline Disposal Impacts</u>

<u>a) Land Use</u>

Shoreline disposal facilities may impact uses on many hectares of surrounding land and/or water, altering the physical character of a site substantially. While the site may be in active use for only a few years, it will probably be necessary for it to continue its function (isolating contaminants from the biosphere) indefinitely. Long term land and water use of the area will thus be constrained to some degree.

<u>b) Physical Impacts</u>

The physical impact of a shoreline disposal can be greater than the impacts from shoreline stabilization projects as discussed in section 7.1. Depending on the new shoreline configuration and the distance offshore, the disposal could disrupt littoral processes, and some nearshore aquatic habitat will be lost as the nearshore slope is replaced with a land area with steep sloping armoured sides.

<u>c) Water Quality</u>

There are direct water quality impacts from both the construction and operation of confined disposal facilities. Construction would proceed through construction of dykes to enclose the site. In extreme cases, soft sediment may have to be dredged to provide a stable base, but generally the dyke will be built by directly dumping rock or earth material in the desired configuration. The water quality impacts, which are normally minimal for rock fill, are greater when earth fill is used and includes turbidity resulting from the loss of fine material to the water column. Any contaminants associated with the fill will also be released to the water column. Therefore, any materials used in construction of the perimeter walls must meet the Fill Quality Guidelines for Lakefilling.

<u>Recommendations for Mitigation of Disposal Impacts.</u>

<u>a) Land Use</u>

Long term land use must be considered at the site selection stage. Consideration should be given to both the operational characteristics of the site and its ultimate use. In some cases dredged material can be a resource to be used in creating an end use, such as industrial land.

<u>b) Physical Impacts</u>

The most effective way to mitigate the physical

impact of a shoreline disposal is to minimize its impact on the littoral zone. The size and shape should not block littoral drift. The new shoreline should be stabilized without enhancing downdrift erosion. Siting should preclude the burial of important aquatic habitats like marshes or fish spawning areas.

c) Water Quality Impacts

Sites which are to be filled with contaminated dredged material over a long period should be compartmentalized to minimize exposure to the contaminants. This is especially important for semi-confined disposals which remain accessible to aquatic organisms. Gaps into the disposal compartment should be closed when not actually in use for barge traffic. Closure can be achieved by using a temporary berm when the structure is not in use for a prolonged period.

The key to preventing water quality degradation during disposal site construction is to prevent losses of the dyking material. This is seldom a problem for rock or slag dykes, but earth dykes will require prompt application of erosion control measures.

Material disposal within the structure should be at a rate that does not permit the structure to overflow. Therefore, filling should be maintained at a rate that does not exceed the ability of permeable berms to pass the flow.

The amount of water to be disposed of is substantially reduced if the dredged materials are handled mechanically rather than hydraulically. For hydraulic operations, the disposal should incorporate an effluent settling basin to provide adequate settling when the main cell is full. Studies of confined disposal basins on the St. Clair River found that mercury losses through rock dykes lined with gravel and filter fabric were at least as low as the losses via the direct overflow from a secondary settling lagoon. Losses at the same site when dredged materials were placed mechanically were negligible.

Adjustable weirs, if properly serviced, will provide better effluent quality than simple outfall pipes. Good performance has been achieved by incorporating screens of filter fabric into the weir. The weir should be positioned to maximize the flow path (and thus the settling time) from the influent pipe. Where these measures cannot provide acceptable effluent quality, it may be necessary to add chemical coagulants to enhance settling.

Where feasible, a layer of low cover vegetation between the outfall and the receiving watercourse will provide some additional removal of particulate material.

By dredging the poorest quality material first and capping it with better quality material, best use will be made of a site's initial settling capacity. This practise will also minimize the need for a covering layer of clean fill to prevent biological uptake in plants and contaminant losses through surface erosion.

Consideration must be given to protecting ground water quality. Most nearshore disposals will not create significant hydraulic gradients, but it may still be advisable to supply an appropriate covering layer over mobile contaminants to prevent infiltration.

Dykes are normally built as narrow as possible to maximize internal capacity and minimize construction costs. It is imperative that the dykes be capable of withstanding internal hydraulic pressures, seepage, and erosion from internal and external waves. Determination of the dyke height must consider the possibility of overdredging (up to 25% is not uncommon); expansion of the dredged material vs. its in-situ volume; settling of the dyke itself, and; sufficient freeboard to prevent overtopping by waves.

Within the confined disposal facility, water quality will deteriorate to a degree determined by the dredged material quality and the method and rate of placement within the CDF. At semi-confined sites, the degree of circulation with the parent waterbody will be a further factor. Water quality may become so poor as to be directly lethal to aquatic organisms. In any case, most sites are designed to become dry land, thus eliminating all aquatic organisms. Contaminant uptake during the interim period (which may exceed 10 years) poses a potential threat to birds and animals which prey on aquatic organisms within the disposal (and to fish in the case of semi-confined disposals).

Most confined disposal facilities, especially those filled by hydraulic dredges, will have a direct discharge back to the watercourse. The discharge may be in the form of seepage through the dyke medium or via an outlet structure. In the final stages of hydraulically filling a disposal cell, much of the

settling capacity of a site has been lost and the overflow quality is poor.

Dyke failure is not uncommon, particularly on low cost projects using earth fill dykes. The sudden release of the disposal site contents can have serious adverse effects and must be prevented. Most of the potential structural problems associated with confined disposal areas can be mitigated through careful planning, design, and the appropriate size and type of material. Each project must be assessed on a site- and case-specific basis.

7.3 Lakefills and Piers

Included in this section are all temporary and permanent structures placed in a watercourse such as lakefills, piers, docks, causeways, and cofferdams.

Lakefills are land masses created by dumping earth and rubble fill into a lake. The term landfill is sometimes applied to this activity but is avoided here since it leads to confusion with sanitary landfills. Lakefills are different from most engineered marine structures in that earth and rubble are often left exposed to wave action with only minimal conventional shore protection. In most cases, the designers attempt to create "stable" beaches and place armour stone only at hardpoints at the ends of beaches.

Piers and docks are structures built to provide berthing space for ships. While they may incorporate fill, at least part of the structure will have a vertical face at which ships can tie up to load and/or unload cargo. Cargo handling equipment such as cranes, hoppers, conveyors, or pipelines are often provided. Piers may be extended well out from shore to shipping depths (about 9m for full size Great Lakes vessels) to minimize dredging requirements. The availability of local materials, the commodity to be transferred and site constraints will determine the method of pier construction.

Causeways are berms or raised roadways connecting two land masses or an offshore structure to the shore. Causeways are called for where water depths and the supply of fill material make them more attractive than bridges.

Cofferdams are temporary barriers built to allow the dewatering of an area of lake bottom, usually for construction in the dry of another structure. Cofferdams range from simple earth berms to elaborate interconnected cells of steel sheet piling.

7.3.1 Lakefills

Impacts

Many of the impacts associated with shoreline dredged material disposal facilities described previously are common to lakefills. Lakefills result in a permanent change from aquatic habitat to terrestrial habitat and a change from a natural shoreline to an artificial one which may have high maintenance requirements.

In the 1970's and 1980's, the construction of lakefills for recreational use was common around the heavily developed shoreline of western Lake Ontario. Each of the lakefills constructed during that period incorporated a basin to provide a small craft harbour, while the remainder of the site was left open for passive use. Water quality in the artificially created basins can be significantly worse than in the adjacent lake, most often as a result of inadequate design that did not provide for sufficient water exchange. Often this was aggravated by the location of waste water discharges, including storm sewers, either in the lakefill structure or nearby. The location and configuration of the embayments created as part of the lakefill thus often resulted in the trapping of discharge water from these sources.

The filling activity itself has adverse impacts on water quality, such as increased turbidity and suspended solids, due to the loss of fill. Lakefill sites have in the past accepted earth and rubble from private and public sector construction projects and visual site inspection alone has not been sufficient to maintain adequate control over the quality of fill. Excavations for roads, railroads, sewers, and redevelopment of industrial sites are all potential sources of contaminated fill.

The magnitude of fill losses to the water column varies from site to site and by season. Dumping of earth fill during stormy weather can result in losses of significant quantities (or all) of the fill material. The chemical quality of the fill material can directly affect water quality in the area of the lakefill structure

through the introduction of contaminants into the water column.

Sediment quality is affected as eroded fill settles to the bottom. Fluid sediment in the bottom waters moves downslope from the dump face as a density current and disperses offshore. The exposed face of most lakefills is a non-depositional zone for most fine-grained materials, but some accumulation may develop during calm periods. Embayments and enclosed boat basins will provide a depositional environment and will accumulate fine-grained sediments. The chemical quality of the sediments will reflect the chemical quality of the fill material and the quality of nearby sources such as sewer discharges.

The introduction of contaminants in fill into the aquatic environment can degrade water quality through the suspension of contaminated fill, and thus increase the availability of such compounds to aquatic life. Deposition of contaminated fill in the bottom sediments can affect sediment-dwelling organisms through direct lethal effects, and can also act as a long-term source to the water column or aquatic organisms.

The impact on littoral zone habitat can be substantial. A given site may extend several kilometres offshore to water depths of 15m and may directly bury many hectares of lake bottom, directly affecting fish and benthic habitat. The lakefill may alter nearshore current patterns such that dispersion of wastes from existing outfalls is affected.

Lakefills built on shorelines subject to littoral transport typically block that transport. The accumulation of material on the updrift side may interfere with intakes, outfalls and aquatic habitats. Erosion on the downdrift side may necessitate remedial measures.

Mitigation Measures

Siting of a lakefill is critically important. Long term land and water uses need to be carefully considered to ensure compatibility with the proposed structure and its likely uses. In developing areas, it is important to assess the impact of a lakefill on ongoing or planned water management programs. For example, continued dumping of earth fill is incompatible with measures to control shoreline and upstream sources of sediment loadings to the Great Lakes. Recreational water use at some lakefills can actually be impaired by the construction of the facility designed to enhance it. Impaired dispersion of nearby effluents, discharges of storm water to the site, and turbidity from erosion may restrict swimming and board sailing and may even make small craft boating less desirable.

Siting also needs to consider all other local water and shoreline uses. The impacts of a lakefill structure are likely to extend well beyond the boundaries of the structure itself. The cumulative impact of all shoreline and water uses should be considered during the planning stage. Assessment of cumulative impact would include both updrift and downdrift changes in sediment accumulation and erosion through altering shoreline currents (eg., through creation of embayments); potential changes in water quality; and fish habitat alteration.

Water quality within the enclosed boat basins will be discussed at greater length in Section 7.4 - Marinas. Circulation between the basin and the lake should be kept as high as possible while providing a safe haven for boats. Direct discharges to the basin should be avoided. Embayments, which may be created on either side of the lakefill, will usually have poorer water quality than that of the open lake. Avoiding discharges to these areas will help maintain water quality. The lakefill should be located such that discharges from existing outfalls will not detract from the desired uses of the proposed embayment.

Three methods of construction have been used to construct lakefills: Fully Exposed, Partially Exposed and Fully Enclosed. The most common method used along the Toronto Waterfront is the Partially Enclosed method where an access spine is constructed along the perimeter that is exposed to the predominant storm wave direction to act as a barrier.

Existing practice for construction of large lakefills is to construct the core of the spine with earthen materials and to later protect or armour the spine with quarry rock or concrete rubble. The protection is commonly advanced along with the filling such that active filling occurs only along a 15 m exposed face. Armouring materials must be kept stockpiled on the site such that the fill face can be protected as quickly as possible once filling is complete. This also enables the fill face to be protected quickly in the event of an approaching storm.

The Fully Enclosed method is the most expensive and is usually used only for construction of CDFs where protection for contaminated fill is required.

Due to potentially high fill loss the Fully Exposed method is seldom used.

Sampling for chemical analysis of the parameters listed in Appendix A of the Fill Quality Guidelines must be undertaken at the site and approval to dispose of the material in a lakefill must be obtained before any material can be moved to the lakefill. If material is destined for use as Unconfined Fill as defined in the Fill Quality Guidelines then the material must also pass the required tests as laid out in the Guidelines. Disposal of the fill at the lakefill site must also be done in accordance with the other criteria laid out in the Fill Quality Guidelines (i.e. turbidity criteria, etc.).

There should always be an available supply of coarse material, preferably quarry stone, to protect the active earth fill face. If construction rubble is proposed, then the site history of the material will determine whether the material will be acceptable without further testing or whether a receiving water simulation test will be required.

Lakefilling techniques were developed by the Toronto Harbour Commission (THC) in the 1950's and refined in the 1970's to minimize environmental impacts. The THC indicates that three rules are to be met to achieve relatively stable beach slopes that are subject only to slow attrition and losses caused by abrasion and weathering:

1) An anchor or hardpoint at each end of a beach to prevent the longshore escape of material.
2) The enclosed beach should describe an arc of a circle of about 15°.
3) The beach slope material grain size must be compatible with the gradient - the larger the material the steeper the allowable slope.

To minimize fill losses from this type of lakefill project, it is desirable to construct the hardpoints as soon as possible. The beaches will likely require years of feeding with the correct size of material to achieve stable slopes, and routine maintenance as materials are eroded.

Fill losses (and thus contaminant loss and turbidity levels) are more effectively controlled by placing earth fill behind a protective rubble berm. The disadvantage is that as water depth increases, the amount of rubble required to build the berm becomes significantly greater than the amount of rubble required to cover an existing slope. Where there is an ample supply of rubble material, this is the preferred option.

7.3.2 Piers

Impacts

Few of the water quality concerns associated with lakefills occur with piers and docks. Earth fill, if used at all, is promptly protected from erosion. However, where earth fill is used behind permeable barriers, the material used must meet the Fill Quality Guidelines. Since construction periods are relatively short and seldom extend beyond one year, effects during the construction period will be minimal.

Since the main function of the pier is to facilitate the transfer of cargo from ships to shore, it is not necessary to create a land mass in the watercourse. Indeed it may be feasible to build the pier on pilings. Where the pier is a solid structure, the considerations of impact on littoral transport and direct loss of habitat apply.

Mitigation Measures

At a dock or pier littoral transport problems can be minimized by making the structure sufficiently open. The pier can incorporate a bridge section near shore, be raised on piles, or be built of cribs interconnected above the water. The same remedies avoid interference with wastewater discharges and fish migration patterns.

7.3.3 Causeways

Impacts

Causeways may be built of earth or rock fill. The water quality impacts during construction will depend on the nature of the fill, the severity of exposure to wave attack, and the duration of construction. The post-construction impacts may be significant since causeways are most often used to make connections between mainland and islands or structures in

shallow, biologically productive environments. By its nature, causeway construction restricts water movement which can result in water quality impairment and loss of aquatic habitat.

Mitigation Measures

Use of earth fill to construct a causeway will cause some of the water quality impacts attributed to lakefills, such as loss of fine-grained material (turbidity). These are minimized by providing slope protection to prevent erosion. Culverts or bridge segments can be used to allow water movement and fish passage through a causeway. Unless there is a defined channel where flow is concentrated, the degree of circulation afforded by these measures will be considerably less than existed previously.

7.3.4 Cofferdams

Impacts

Cofferdams built of earth fill are subject to the same water quality problems as lakefills, although over a much shorter time period. Rock-fill cofferdams will probably require some earth fill to provide a seal which will allow dewatering. Placement of the cofferdams may have to be staged to allow the flow of water for other water uses (including migratory fish). Water pumped out of the cofferdam may have to be directed to a settling basin or otherwise restricted if it has become highly turbid or contaminated from excavation work within the cofferdam. Closing off an area with a cofferdam may trap a resident fish population. Water quality impacts of cofferdam removal will be comparable to those for initial construction. While the cofferdam is in place, sediment generated by construction activities may accumulate around it.

Mitigation Measures

Earth fill cofferdams should only be used where the material is not subject to erosion. Earth fill is not appropriate, for example, in a fast flowing stream.

Where excavation is to take place within a cofferdam it is desirable to dewater the area as much as possible first to avoid excessive turbidity in the water and to allow dry handling of the excavated material. If fish have been trapped within the cofferdam, they can be rescued by seine netting at low water levels and transferred back to open water.

During removal of a cofferdam, the earth seal or core should be removed first, rather than at the same time as the rock fill. If sediment has accumulated against the cofferdam, it may be necessary to remove it prior to removing the cofferdam to avoid a slug of sediment being washed downstream when normal flow conditions are restored. Sediment containment devices, such as silt curtains, may be required during removal.

Steel sheet pile cofferdams have negligible direct water quality impacts and their use may be applicable in sensitive aquatic habitats, high stream flow conditions, or restricted areas where an earth and rock berm would require too much space.

7.4 Harbours and Marinas

A harbour, whether a natural area of refuge, a commercial port, or a recreational marina, by definition is a water area partially enclosed and so protected from storms as to provide safe and suitable accommodation for vessels. Natural harbours may exist at embayments (e.g., Hamilton) in the lee of islands (e.g., Toronto), or at river mouths (e.g., Whitby, Oshawa, Grand Bend). Artificial harbours may be developed by constructing offshore breakwaters (e.g., Port Credit, Thornbury) or excavating basins behind the original shoreline (e.g., Fifty Point, Lagoon City). Typically in Ontario, natural harbours have been artificially enlarged by the construction of breakwaters and by dredging to accommodate the increase in size of commercial vessels, or the increase in numbers of pleasure boats. As natural sites have been fully developed (particularly in western Lake Ontario), completely artificial harbours are being constructed in areas which were previously exposed open shoreline (Bluffers Park, Fifty Point).

7.4.1 Harbour Construction Activities

This applies to both commercial and marina construction. A major difference is the added emphasis at the marina on maintaining water quality to enhance the recreational experience.

a) Siting Considerations

Compatible land uses. Commercial port facilities require land transportation services and may need buffering from other uses. Marinas may be incompatible with natural areas or heavily industrialized areas.

Compatible water uses. Avoid conflicts with water supply and waste disposal. Harbour development in river mouths may conflict with flood control. Recreational boating may interfere with the use of bathing areas or with commercial vessel traffic.

Water Movement. Water circulation in slips or marina basins will be necessary to prevent water quality deterioration. This can be difficult to achieve since harbours must minimize wind driven waves and currents to shelter boats. Circulation is easiest to achieve where multiple openings to the boat basin can be provided to take advantage of prevailing currents.

Coastal Processes. A thorough understanding of coastal processes and stream sedimentation patterns at the site is necessary to produce a design with minimum long term maintenance requirements. When that option does not exist, long term disposal capacity for contaminated dredged material should be designed into the project.

b) Dredging

Dredging is the most common component of harbour construction. The details of dredging and dredged material disposal are discussed at length in the MOEE publication "Evaluating Construction Activities Impacting on Water Resources Part III" and are not discussed in detail here. Disposal of harbour sediments must be done in accordance with the methods laid out in the "Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario".

c) Filling

Filling operations typically accompany dredging in the creation of harbours. An area of open flat land as large as the water area will be required for commodity storage, parking, winter boat storage, etc. This land area has most often been obtained by filling in wetlands or adjacent shallow water. However, under the Provincial Wetlands Policy this may no longer be possible. The proponent should refer to Section 7.3 and the "Fill Quality Guidelines for Lakefilling in Ontario" for further details regarding filling.

d) Shoreline Treatment

Most harbour facilities will require some areas of vertical bulkheaded walls for berthing. Such walls should be designed to maintain the integrity of the backfill by using the equivalent of interlocking sheet piles or by placing filter fabric against the inside of the wall.

Where space permits, energy expending beaches inside the basin will decrease reflected waves. Such beaches should be sufficiently coarse to maintain their slope without extensive maintenance. All earth banks should receive some protection to prevent erosion and subsequent water quality deterioration. In some instances appropriate planting may suffice.

e) Site Services

It should be appreciated that many boat owners will spend most of their "boating" time at the marina dock socializing as though the boat were a cottage. Accordingly, the need for onshore facilities will be considerable. Washrooms and showers will often be supplemented with a laundromat, supplies store, clubhouse and restaurant. Demand for sewage facilities may be as great as in a cottage subdivision.

Probably every marina will offer fuel sales. The fuel dock should be designed to minimize the impact of potential spills while complying with safety requirements related to fire and explosions.

Waste holding tank pumpout facilities will be required with discharge to approved onshore facilities.

Every effort should be made to prevent the direct discharge of contaminants to the boat basin. Seepage from septic tanks or even surface runoff from parking lots and work areas can degrade water quality in a boat basin with limited water circulation.

At commercial docks cargo handling facilities become important, especially for bulk commodities. Provisions to prevent spillage, control dust and collect surface runoff will be necessary to protect water quality.

Mitigation of Impacts

a) General Considerations

Protection of adjacent wetlands must be carefully assessed during a harbour construction. These biologically productive areas have an important role to play in efforts to rehabilitate aquatic habitat, especially in the lower Great Lakes. Some success has recently been achieved in creating new wetlands, however, little long term data are available on their performance compared to mature natural marshes. The littoral zone habitat is under considerable stress from competing water uses and efforts should be made to minimize additional stresses that may be created through interference with natural wetlands. Construction in the littoral zone may offer the opportunity to upgrade the quality of the habitat by providing artificial spawning shoals and reef refuges.

Provision of adequate circulation will dominate water quality considerations in a new harbour or marina basin. The American Society of Civil Engineers recommends a preferred flushing rate of 2 times daily. In the Great Lakes non-tidal situation, this will often be difficult to achieve. The U.S. Corps of Engineers suggests that for single entrance harbours, an average daily exchange of water equivalent to one third of the harbour volume will be sufficient to prevent stagnation. They further recommend that where water level fluctuations are small, two entrances designed to catch wind generated currents such that a complete exchange of water occurs every ten days will usually be adequate.

Major harbour construction on the exposed shoreline of the Great Lakes often merits evaluation in a hydraulic model. Water quality considerations should be examined along with the coastal engineering aspects. Some mathematical models are available to examine water exchange and predict water quality.

In situations where no natural means of circulation are available to overcome foreseen water quality problems, flows may be artificially induced by pumping.

Any harbour structure is likely to have some impact on coastal processes, requiring mitigation. The most common impact is the interruption of littoral drift by the construction of breakwaters or entrance jetties across the littoral zone. Unless the structure can be located at a nodal point where there is no net drift (or on a rocky shoreline where there is none at all) it will be necessary to bypass sand from the updrift accumulation area to the downdrift erosional area.

Littoral drift characteristics must be balanced against safe entrance considerations in designing a harbour mouth that is not prone to shoaling.

New facilities located on the busy shores of the Great Lakes are likely to be impacted to some degree by existing water uses. Municipal and industrial discharge plumes may limit recreational water use. Careful evaluation of existing water quality conditions are advisable.

b) Dredging

Impact mitigation measures are discussed in greater detail in the dredging guidelines (Evaluating Construction Activities Impacting on Water Resources Part III: Guidelines for Dredging and Dredged Material Disposal). A few principles are discussed below.

Where wet excavation in silt and clay is necessary, mechanical dredges (backhoes, clamshells and to a lesser degree draglines) are preferable to hydraulic dredges. Hydraulic dredges maximize soil contact with the water, creating more turbidity and increasing adverse impacts of contaminants associated with the sediment. With hydraulic dredging of fine grained sediment, one or more settling ponds will be needed to obtain an effluent of acceptable quality for release back to the watercourse. Keeping the spoils as dry as possible, especially by excavating in the dry, improves the load carrying capacity of the excavated material which facilitates beneficial uses around the site.

c) Filling

Construction should be scheduled such that perimeter bulkheads and revetments are built first to retain fill.

Grading surfaces away from the waters edge to settling ponds, catch basins, and ditches will minimize siltation in the harbour.

Fill used in the construction of the harbour must

meet the applicable guidelines in the MOEE Guidelines for Management of Excess Soil, Rock and Like Materials and the MOEE Fill Quality Guidelines for Lakefilling in Ontario.

d) Shoreline Treatment

From an environmental standpoint, the best shoreline treatment will be one that gives long term protection against erosion, is itself inert, and requires little maintenance. Numerous materials meet those requirements and selection will depend on site and cost considerations. For vertical walls, steel sheet piling and soldier piles with precast concrete panels have proven effective. On sloping revetments, appropriately sized local stone is all that may be required.

e) Site Services

The most important mitigative measures in this category are steps to prevent access of contaminants to the water.

Sanitary sewage should be directed to a municipal system or extra precautions taken in the design of an on-site system.

Storm drainage should be directed away from a confined basin. If it must discharge to the basin, it should do so through regularly maintained catch basins rather than overland flow. Consider that the parking lots will probably be used for winter storage of boats and a component of that is annual replacement of bottom antifouling paints. Antifouling compounds can affect water quality if allowed to enter a water course.

Heat and nutrient inputs to the basin should be avoided to minimize algal growth. Regularly emptied waste receptacles will be required throughout the marina. Marina users (and especially an on-site repair facility) generate significant quantities of waste paint, solvents, cleaning compounds, wood preservatives, used oil, etc., that must be kept away from the water.

A launch ramp will require a hard bottom to prevent erosion. It should be located in an area of good circulation since it generates unavoidable inputs to the water. If provisions are made for washing off hauled boats, the runoff should be directed to the storm water system away from the basin.

Finally, an effective landscaping treatment will do much to enhance environmental quality. Planting can be designed to reduce wind, dust, noise, and erosion. A secondary benefit is an attitude engendered in users which encourages good housekeeping habits.

7.5 Water Intakes

Water intakes are built to provide a steady supply of municipal potable water, industrial process water and cooling water. Offshore intakes range in size from small diameter unburied lines terminating in a simple crib inlet to a 7m diameter tunnel under the lake bottom terminating in a 50m diameter intake cap. Offshore intakes are used to avoid having to draw poorer quality nearshore water and used also to obtain sufficient depth to avoid frazil ice problems. Shoreline intakes are usually used when water volume requirements are high and quality requirements are not stringent (e.g., for cooling water). Fossil and nuclear fuelled thermal generating stations have by far the greatest water requirements of all water users. Pickering Nuclear Generating Station A can draw as much as 114 m^3/second.

Impacts and Mitigation Measures

Construction of unburied water intake pipes has minimal water quality impact. Usually there will be some kind of inlet crib or bellmouth to keep the inlet off the bottom. The inlet needs to be screened to prevent entrainment of debris and fish. Excavation may be necessary at the shoreline to effect the transition from offshore to onshore. The trench should be promptly backfilled to its original contours and protected from erosion. Surplus excavated material should be disposed of onshore such that it does not erode into the water.

Intakes laid in a trench will have impacts related to the scale of the dredging operation required to create the trench. Unless the surficial sediments are contaminated and require special handling, the trench excavations will be placed to one side and re-used as backfill to cover the pipe. Contractors should be encouraged to carry out this operation underwater, rather than bringing the material to the surface and then dropping it back down through the water column. Trench material may have to be supplemented with coarser backfill in nearshore areas subject to scour. Where rock backfill is to be used over the pipe the

potential exists to create desirable fish habitat. The Ministry of Natural Resources should be consulted in this regard.

The availability of mechanical tunnelling "moles" has made it attractive to construct large diameter intakes by tunnelling under the lake bed from shore. In this instance, all of the excavated material is disposed of onshore except for the riser up through the lake bed. Drilling and blasting will likely be necessary to complete the riser. The intake is completed by installing an intake cap over the riser.

All intakes have the potential to entrain fish, particularly larval fish. The intake should be located away from fish spawning areas and designed to avoid entrainment. At plants with warm water outfalls that attract fish, it is especially important to keep the intake from drawing in resident fish populations.

Some intakes (like Pickering G.S.) use groynes or jetties to extend beyond the nearshore zone. These can impact the littoral zone in the same manner as groynes built for shore protection.

Dredging and blasting operations should be scheduled to minimize impacts on resident and migratory fish species (underwater blasting will require prior approval by DFO).

7.6 Wastewater Outfalls

Wastewater outfalls are built to direct stormwater, sanitary waste, industrial waste and cooling water into a watercourse for dispersion and dilution. For weak waste streams, a shoreline outfall may be all that is required to meet the Provincial Water Quality Objectives/Guidelines. Most sewage treatment plants and many industrial waste streams require a submerged offshore discharge to achieve adequate dispersion and dilution. The outfall may employ a multi-port diffuser to enhance initial mixing.

Offshore discharges are constructed by laying a pipe on the bottom or in a prepared trench or by tunnelling out from shore.

Impacts and Mitigation Measures

Outfall construction shares the same techniques and impacts as intake construction described in Section 7.5. The impact of construction is probably less than from its operation whereas, for intakes, the reverse is often true.

Important considerations for outfall construction relate to the long term integrity of the structure with a minimum of maintenance to ensure that it performs as designed. Areas which allow sedimentation should be avoided to prevent blockage of the outlet port(s). Conversely, areas subject to scour could lead to failure of the outfall.

7.7 Offshore Drilling

Offshore drilling refers primarily to drilling exploration and production wells for natural gas in Lake Erie. As of the mid-1980's some 360 producing wells in Lake Erie accounted for more than 70% of the total gas production in the province (although Ontario produced less than 2% of its consumption). Ontario does not permit the development of offshore oil wells.

During the winter months, drilling is also conducted on lakes in Ontario for purposes of mineral exploration.

Once a promising formation has been identified by seismic surveys an exploratory well is drilled. Since Lake Erie water depths are not excessive (most wells are in less than 40 m), the preferred drilling technology is with a rotary rig on a self elevating barge. The technology is well developed and has been practised on Lake Erie for more than 40 years. Elsewhere in the world, wells are now being drilled to over 300m depths from fixed-leg platforms while semi-submersibles are operating in depths in excess of 1400m.

The rotary drill rig consists of a derrick, hoisting mechanisms to raise and lower the drill pipe, and a turntable on the derrick floor which turns the drill pipe. A drill bit on the bottom of the drill pipe grinds the rock at the bottom of the drill hole. Drilling fluid or "mud" is continuously pumped down through the drill pipe, out the bit, and back to the surface between the drill pipe and the casing. The mud cools and lubricates the bit, carries away the drill cuttings and plasters the wall of the bore hole with a stiff cake of mud to lessen the chance of a cave-in. Additionally

the mud provides the hydrostatic pressure necessary to keep the well under control. The mud's main constituents are viscosifiers (bentonite), weighting agents (barium sulphate), fluid loss control agents like shredded cellophane or wood fibre, thinners such as ferrochrome lignosulphonate, and caustic soda for pH control. In special circumstances surfactants, defoaming agents, lubricants and bactericides may also be added. The bentonite typically accounts for 60 to 90% by weight of all the additives.

The drill cuttings are separated from the drilling fluid by screens and hydrocyclones and discharged. Some mud will also be discharged as it accumulates colloidal particles and becomes too viscous.

If the well is a producing well then production casing is set down the length of the well and cemented in near the bottom of the hole. The well head on the lake bottom connects the producing well to pipelines to shore.

To stimulate the flow of gas to the well the productive formation may be acidized or fractured. Acidizing involves pumping acid down the well under pressure to dissolve channels in limestone of low permeability.

Fracturing is done by forcing sand grains in a fluid suspension under high pressure into the rock formation. The sand grains wedge the fractures open leaving the formation with greater permeability.

Impacts and Mitigation Measures

The environmental impacts of this type of drilling are minimal if good housekeeping practices are adhered to and no accidents occur.

The drill hole needs to be properly cased to prevent the possibility of fresh groundwater being contaminated with sulphurous saline water likely encountered at depth.

The drilling platform must be designed to withstand the severe wave climate to which it may be exposed. Unless the platform is designed to withstand ice loadings, work must be restricted to the ice-free period.

Drip pans and other collection and holding tanks shall be provided as necessary to collect fluid spills (mud, lubricants, fuels) and retain them until they can be disposed of on-shore in an approved manner.

Any oil-based drilling muds must be disposed of at approved on-shore facilities.

The bulk of the discharged drill cuttings and mud descend rapidly to the lake bottom with minimal impact on water quality. No significant accumulation on the bottom would be anticipated in the shallow water energy regime of Lake Erie. Impacts on the benthos should be minor and localized.

Sewage and trash are to be disposed of at approved facilities on shore.

Re-entry holes and abandoned holes should be plugged so that fluids from one level will not migrate to other levels or to surface waters.

Well heads should be recessed into the lake bottom such that they do not obstruct commercial fishing.

7.8 Underwater Blasting

Underwater blasting is undertaken for three primary reasons: rock excavation, demolition, and seismic surveying. Proponents need to be aware that underwater blasting may require approval from the Canada Department of Fisheries and Oceans due to potential effects on fish.

In its most common application, rock excavation, explosives are usually placed in drilled holes to fragment rock into pieces suitable for subsequent excavation by dredge. The fragmentation size and rock type will determine the blast ratio. Typical blast ratios range from 0.5 kg explosive/cubic metre in soft sedimentary rock to 1.8 kg/m^3 in granite.

For underwater demolition work, the explosive charges will more likely be placed on the surface of the object to be demolished (e.g., boulders, sunken vessels obstructing navigation). Such blasting is less effective since it depends entirely on the shattering effect of the detonation wave and the gases produced are largely dissipated in the water. Shaped charges improve this performance but their expense limits them to special applications like cutting off pilings.

In seismic surveys, explosives may be detonated in the water column or on the bottom to serve as an acoustic source for subsequent measurements of reflected and refracted energy.

Impacts

An underwater explosion produces a positive pressure wave immediately followed by a negative pressure wave. This sudden change in pressure can be lethal to fish in the vicinity. The rate of pressure change appears to determine lethality more than the magnitude of the pressure change. The rate of pressure change is determined by an explosive's characteristic detonation velocity, some of which are shown below.

Black powder blasts have little effect on fish. Monitored overpressures as high as 1100 Kpa have not produced mortalities compared to minimum lethal pressures in the range of 276 Kpa for dynamite and 30 to 150 Kpa for C.I.L. Hydromex.

Charges placed in a stemmed drill hole lose most of their energy fracturing the rock and thus produce smaller pressure changes than unconfined charges.

The peak overpressure can be approximated by the following formula developed by R.H. Cole (1948):

$$P = f\,(w^{0.33}/R)^{1.14}$$

where P= Peak overpressure in KPa

W= Weight of explosive per delay period in kg

R= Distance between shot and observation point in m.

f= an experimentally determined constant.

In 54 overpressure measurements at Nanticoke during construction of the Stelco dock in 1975, VME Associates (1976) determined f to be 733.7 for those site conditions and Hydromex explosive. Observations of caged and resident fish indicated an overpressure range associated with acute internal injury to fish was 30 KPa to 150 KPa. Over a radius of 20 to 45 m mortality was 100% while 10% to 20% mortality occurred at a radius of 45m to 110m (for blasts as great as 272 Kg per delay).

The injuries fish sustained were ruptured swim bladders and haemorrhaging in the coelomic and pericardial cavities. Laterally compressed species (white bass, pumpkinseed) were more susceptible to blast pressure gradients than were the fusiform fishes (rainbow trout, white sucker). Swim bladders often burst outward suggesting the fish withstood the positive pressure wave, then succumbed to the negative (Telecki and Chamberlain 1978).

About half of the fish killed in an underwater blast will sink rather than float to the surface.

Some injured fish will survive for several hours and thus would not be observed in a post blast mortality survey. Stunned fish which might otherwise survive their injuries are very vulnerable to herring gull predation.

Unburied charges have a higher fatality radius than buried charges. In an experimental application of shaped 9 kg high explosive charges set on rock bottom in Lake Erie in 1976, the lethal radius has been estimated at 122 m. Ferguson (1962) reports fish kills 60 m from only 0.5 kg of high explosive. Falk and Lawrence (1973) indicate that a lethal radius as great as 914 m has been reported for 1814 kg of Geogel (high explosive) place on the lake bottom.

By comparison the 1958 explosion of 1,247,379 kg of Dupont Nitramex 2-H buried under Ripple Rock reportedly had a lethal radius of only 805 m.

In some instances the lethal radius for buried charges has been reported as being smaller near the bottom than in surface waters. This may be related to the propagation of the pressure wave, the fact that fish in the water column are more likely to have swim bladders and are thus more susceptible than bottom fish, or may simply reflect the difficulty of adequately surveying the bottom fish.

Sculpins, crayfish, clams and snails have been observed within 5 m of a high explosive blast minutes after the detonation showing no ill effects.

Structural damage caused by blasting is usually the result of vibration. Energy from the detonated explosive is transmitted from one particle to another as elastic waves. The resulting movement in the rock and overlying structures is inversely proportional to the distance from the blast. Damage is more a function of particle velocity than amplitude. A particle velocity of 5 cm/sec. is considered a safe level of vibration for normal residential structures. Bridges,

dams, and docks should be able to safely withstand velocities of 15 cm/sec.

The third cause of damage from blasting (after water pressure and vibration) is flying rock. This is not usually a problem in underwater blasting unless the overlying water is less than 3 m deep.

The direct water quality impact of detonating explosives underwater is minimal. There may be short term increases in nitrites and carbon dioxide, but these disperse rapidly. The indirect effect of mixing poor quality sediment overburden into the water column is seldom significant in rock excavation areas.

Mitigation Measures

When blasting rock (or hard till etc.) the adverse affect on fish will be minimized by avoiding the release of energy beyond that needed to break the rock. To achieve this end charges placed in drilled holes and stemmed are preferable to surface charges.

Monitoring of blasting operations over several weeks at South Baymouth and Nanticoke found that fish mortality declined after the first few blasts. It is postulated that elevated levels of turbidity from the drilling and blasting caused fish to avoid the area. This effect may be species dependent as some of the literature suggests predators move into the area to feed on killed fish and were themselves killed in subsequent blasts. A careful evaluation of the habits of fish species occurring in an area can help in devising a blasting program that will have minimal effects.

A solid object in the path of a pressure wave reduces the lethal range of a blast in that direction. The underwater topography of a site may be used to advantage to reduce the blast impact. The production face can be oriented away from sensitive areas.

Using the formula provided in the previous section on Impacts it is possible (after determining the site coefficient f and assuming a lethal overpressure) to determine the lethal radius for a given size of explosive charge. Alternatively, to protect a habitat at a given distance from the blast the maximum charge size can be calculated.

In extreme cases an air bubble curtain can markedly reduce the pressure created by a blast. In open water production blasting, however, air curtains are difficult and expensive to deploy.

The most effective mitigation measure applicable to seismic work is the selection of a non-explosive acoustic source. Three of the more popular devices are described below:

Par Air Gun uses a sudden release of air under high pressure. Lethal radius is estimated at 1 m to 2 m. Shock wave is similar to that from black powder. Tests by the Canada Department of Energy, Mines and Resources showed that a 1000 cubic inch (16,387 cm^3) Air Gun was as effective as 50 lb. (22.68 kg) dynamite charges as a seismic source.

Vapourchoc - Steam is injected at 6 to 12 second intervals into the waterbody to form large bubbles. The bubbles collapse as the steam condenses and the rapidly inflowing water produces an acoustic output.

Flexotir - A 2 oz. (56.68 g) explosive charge is detonated inside a 2 ft. (0.61 m) diameter cast iron sphere 2 in. (50.8 mm) thick perforated with 13 holes about 2 in (50.8 mm) in diameter. The sphere damps the bubble oscillation allowing the device to be considered non-explosive.

7.9 Habitat Enhancement

Projects in support of fish habitat enhancement include the placement of large stones, concrete blocks and used tires within a waterbody for the creation of artificial reefs. From a Provincial perspective such work falls mainly under the mandate of the Ministry of Natural Resources and any fisheries related proposal must be approved by MNR.

Within the last few years there has been increasing interest in the use of scrap tires for various water related projects, but the most significant have been proposals for the construction of artificial reefs. Recent studies (Day *et al.* 1993) have shown that tires (new and used) and even tires that have been placed in water for some time exert a strong toxic influence on aquatic organisms. From this perspective the use of tires in aquatic construction projects is not recommended.

With the exception of quarried material and those designated as inert, most other material for placement in open water must meet the Provincial Sediment Quality Guidelines.

8. OIL AND GAS PIPELINES AND ELECTRICAL/ TELEPHONE CABLES

Oil and gas distribution pipeline projects in the Province of Ontario require the approval of an application by either the Ontario Energy Board (OEB) or the National Energy Board (NEB). With the exception of Permits to Take Water (necessary in for hydrostatic testing) which are issued by MOEE, all MOEE concerns regarding such projects are forwarded to the OEB for inclusion, along with the concerns of other review agencies, in a coordinated response to a project application from a proponent and proponents should make initial contact with the OEB to establish application procedures and regulations. The Ministry of Natural Resources issues the necessary permits for working in water. The Ministry of Natural Resources, together with Department of Fisheries and Oceans have produced guidelines for pipeline water crossings entitled "Fisheries-Related Information Requirements for Pipeline Water Crossings", which are available from DFO.

There is potential for environmental damage due to erosion and sedimentation associated with nearly every phase of pipeline construction. Some phases, such as stream and lake crossings, have the potential to generate significant amounts of sediment.

Crossings, in particular, must be examined on a site-specific basis; general characteristics such as size and flow are not in themselves reliable indicators of watercourse sensitivity. Care must be taken to ensure that each watercourse to be crossed is studied in sufficient detail to allow the best decision to be made regarding crossing technique and post-construction stabilization measures.

8.1 Purpose and Description

Pipeline construction involves a number of activities and these are listed in Table 8.1.

Recommendations

Watercourse crossings should strive for minimal impacts on water quality and water use by:

1. limiting work to the shortest possible construction time
2. scheduling work for the season of least disturbance to the watercourse;
3. limiting instream disturbance; and
4. immediately implementing post-construction stabilization measures.

Usually, the greatest single factor resulting in adverse environmental effects is the lack of a proper plan to prepare the contractor for the actual field conditions.

8.2 Recommendations for Reduction of Watercourse Crossing Impacts

Preconstruction Planning

1. Compile comprehensive site-specific plan to include:

    - proper route selection, including subsurface conditions,
    - timing (in consultation with MOEE and MNR to avoid impacts of fish migration and spawning and water uses),
    - rapid construction techniques,
    - mitigative measures,
    - timely site restoration, including details of interim and final stabilization.

Note: Construction methods involving blasting operations should be approved in advance by all relevant agencies and parties (e.g. MOEE, MNR, Conservation Authority, land owner).

2. Appropriate equipment should be selected to ensure rapid execution of stream crossing operations.
    - operating inappropriately sized equipment

Table 8.1

Operation	Description
Clearing and grubbing	A variety of equipment is used to remove trees, stumps and vegetation from the right-of-way (ROW)
Trenching	Topsoil is selectively removed and stockpiled for use during site restoration and excavation equipment is used to cut the pipeline trench to required specifications (this includes blasting, where necessary). Excavated material is usually stockpiled for use as backfill, although in certain instances material will be trucked away and granular material will be brought in.
Pipe Preparation	The pipe is hauled in from stockpiles and placed end to end, next to the trench. Where necessary, a pipe bending machine is use to bend the pipe to required specifications.
Welding, Cleaning, Coating	The pipe segments are aligned and welded to form a continuous line and rust and dirt are cleaned from the exterior of the pipe. It is then coated and inspected for coating faults.
Lowering-in	The pipe is placed in the trench.
Backfilling	Damaged tiles (or those removed during construction) in nearstream agricultural areas are replaced, and the trench is selectively backfilled so that no material capable of damaging the pipe coating is placed against the pipe.
Hydrostatic Testing	A mechanical scraper is sent through the pipe to remove rust, scales and dirt, then water is pumped into the pipe until a designated pressure is reached. If this pressure is maintained for the allotted test period (e.g., 24 or 48 hours) the line is considered acceptable and the water is discharged. If a leak is indicated through loss of pressure, it is located and repaired and the line retested.
Clean-up and Restoration	Construction-related debris is removed from the ROW and the area is restored to as near preconstruction conditions as possible.

from the stream bed or transferring from one bank to the other can result in degradation to both banks and bed.

3. All site operations should be monitored to ensure:

- compliance with all design details for environmental protection.

- acceptability of minor changes, provided these achieve the same environmental management goal set out in the original

construction plans.

- prior to the start of construction, site meetings should be held between the proponent, the contractor, environmental inspector and government personnel to confirm site specific plan commitments.

Clearing and Grubbing

1. Vegetative cover should be preserved for as long as possible.

2. Locate all accumulated debris and soil away from watercourses. Material should be temporarily stored or disposed of in a manner acceptable to adjacent property owners and/or relevant government agencies (e.g. Ontario Ministry of the Environment and Energy (MOEE), Ontario Ministry of Natural Resources (MNR), local Conservation Authority).

3. Buffer strips of riparian vegetation should be maintained between the construction area and watercourse.

Trenching

1. Crossings should be swiftly executed.

2. Stream crossing method (including "wet" or "dry" methods) should be based on site-specific evaluation. This will include: streamflow, stream width, environmental sensitivity, soil composition, streambank stability, and approach slope.

   - Plugs should be left in place between the instream trench and the onshore main trench leading to the instream trench until immediately prior to the pipe laying operation in order to prevent erosional losses from the main trench gaining access to the watercourse.

   - Antiseep collars (impermeable barriers placed at appropriate intervals to reduce the erosive force of the subsurface flow and encourage infiltration) should be used to impede subsurface drainage and reduce washing out of subsurface material by piping.

3. Dredging operations should not be conducted on prime recreational lakes during periods of peak use. Where applicable, the work may be scheduled to coincide with low water conditions (e.g. following annual drawdown).

   - all material removed from the water must be placed onshore unless the appropriate agency (e.g. MOEE, MNR) approves their instream disposal. The suitability of spoils for open water disposal will be determined according to the PSQGs (MOEE 1993).

   - dredging equipment and techniques should be directed towards those that result in minimal turbidity. MOEE's guidelines on dredging should be consulted prior to commencement of work (MOEE 1991)

   - pipeline trenching by means of high pressure jetting devices is strongly discouraged, since it forces large quantities of sediment into the water column at considerable distances from the crossing site.

Backfilling

1. Stockpile clean backfill material onsite where native material is not suitable for backfill.

   - delays in backfilling can lead to erosion of the trench or slumping of trench walls

   - backfilling should be completed and the area stabilized prior to spring runoff.

   - the backfilled trench should conform to the pre-construction channel configuration to minimize long-term effects

   - excess material should not be disposed of in the watercourse, or anywhere where it could be reintroduced into the watercourse.

Hydrostatic Testing

1. Use of water for hydrostatic testing should also ensure that removal of water from a watercourse does not reduce the discharge to levels that might negatively affect resident fish or benthic populations. Measures should be undertaken to

ensure that the discharge of hydrostatic test water does not adversely affect water quality or cause scouring of the channel.

- use gravel pads, straw bales, and/or discharge water into dense vegetative ground cover to protect stream channel from impacts of high velocity water.

- aquatic biota should be protected from entrainment at the test water intake.

- rust and other materials dislodged during pipeline cleaning should be collected and transported to an acceptable disposal site (if disposal is desired at other than an MOEE approved site a rigorous analysis of the material will be required).

- the concentration of chemicals used in pipeline cleaning should not be toxic to aquatic biota. MOEE or other appropriate regulatory agencies (e.g. MNR) should be consulted on the use of such chemicals.

Note: a Permit to Take Water, issued by the local MOEE office, will be necessary for any testing that will remove more the 50,000 L/day of water.

Clean-up and Restoration

1. The use of rip-rap for stabilization of streambanks should provide protection from the channel bed to the high water line in order to prevent subsequent bank failure due to undercutting or washing out.

    - Rip-rap should be carefully placed on a correctly graded slope from the stream bed up to the high water-line.

    - random dumping of rip-rap material over a streambank generally protects only the region of the bank above water and can cause the entire bank to slump.

2. Aquatic vegetation removed prior to or during the trenching operation should be contained and adequately disposed of on land.

    - Vegetation which is allowed to drift downstream may adversely affect downstream users as the result of flow obstruction or choking of water intakes. Decaying vegetation may also cause odour and aesthetic problems.

9. BRIDGE AND ROAD CONSTRUCTION

This section covers potential impacts from new highway and bridge construction. Section 9.3 covers bridge maintenance activities such as sandblasting and painting.

9.1 Overview of Highway and Bridge Construction Operations

Details of construction operations will depend upon the size of the project and site specific conditions. For the purposes of these guidelines, however, a series of general, interdependent operations have been summarized in Table 9.1.

Mitigation of construction-related impacts can be achieved through a combination of good construction practices and various site specific "control" methods. Mitigation of long-term impacts, on the other hand, is usually best addressed through a combination of careful project design and site restoration.

Specific design requirements for road construction have been developed by the Ontario Ministry of Transportation.

9.2 Mitigation of Potential Impacts

The following recommendations for mitigation of construction-related impacts are presented according to the general sequence of operations as indicated previously.

Planning

Alignment

- minimize the number of watercourse crossings.
- maximize the distance from watercourses, active wells or other water uses.

Table 9.1: General Summary of Highway and Bridge Construction Operations

OPERATION	DESCRIPTION
Clearing and Grubbing	A variety of equipment is used to remove trees and stumps, and other vegetation from the right-of-way (RoW).
Grading	Heavy equipment and/or explosives are used to "cut" and "fill" original topography to the grades specified in contract drawings. "Borrow" material may be required in some cases, while in others disposal of surplus material may be necessary.
Drainage	Excavation of temporary and permanent drainage ditches and stream diversions is undertaken, and culverts and storm sewers are installed.
Preparation of road bed	Heavy equipment is used to compact the surface, and a layer of granular material is installed.
Surfacing	Concrete and/or asphalt paving is installed.
Bridges	Embankments are constructed, foundations are installed and footings, abutments and piers are constructed to support the superstructure and deck.

- maintain crossing as close to a 90° angle to the streambed as possible.
- identify any areas of concern and incorporate any special mitigative measures as may be necessary.

Clearing and Grubbing

• Vegetative cover should be preserved for as long as possible.

• Locate all accumulated debris and soil away from watercourses. Material should be temporarily stored or disposed of in a manner acceptable to adjacent property owners and/or appropriate agencies.

• Buffer strips of riparian vegetation should be maintained between the construction area and watercourse.

• Construction timing and techniques, and design of instream structures should be determined in consultation with appropriate government agencies (e.g. MOEE, MNR) prior to the commencement of any construction activity to minimize potential impacts on fish and other water uses.

Grading

• Disruption of subsurface flow should be minimized through the use of appropriate fill material.

• Newly graded slopes should be protected against erosion as soon as possible (e.g. berms, rip-rap, aggregate cover, seeding, mulching, sodding, vegetation plugs, etc.). Wherever possible stabilization should be part of the grading operation.

• grade and crown grade during construction to shed water and increase erosion resistance.

• Any proposed blasting operation should be undertaken so as to minimize water quality and quantity impacts on local wells and watercourses. Monitoring of potentially affected wells should begin prior to blasting. Note: Any blasting will require prior approval from Canada Department of Fisheries and Oceans.

Drainage

• Complete construction of all temporary and permanent drainage ditches, culverts and sewers as rapidly as possible.

• Incorporate erosion and sediment control measures to ensure that off site impacts are minimized.

• Permanent drainage ditches should be designed to minimize impacts on existing watercourses and ground water by avoiding large cuts, incorporating protection against scour, and avoiding discharges into unprotected watercourses.

Culvert design should incorporate:

- adequate inlet and outlet erosion protection,
- energy dissipation measures to prevent increased downstream velocities.
- invert elevation should provide a sufficient depth of water for the passage of fish at low flows while avoiding backwater effects at peak flows.
- culvert diameter should be sized to accommodate anticipated discharge fluctuations, including those resulting from ice damming or other blockages.

Watercourse rechanneling (i.e. permanent flow diversion).

- avoid watercourse alterations wherever possible.

- all permanent diversion channels should be protected against erosion.

- should incorporate energy dissipation measures and/or downstream erosion protection to prevent scour at (or downstream from) the points of confluence with the old channel.

- dry construction should be used for any new drainageway to prevent sedimentation and slumping of banks.

- the new channel should be completed and all armouring put in place prior to diversion of flow from the existing drainage network.

Dewatering operations.

- minimize impacts on ground and surface water uses by protecting outfalls (e.g., gravel or grass "splash pads") and locating away from erodible areas

Note: The Ontario Water Resources Act provides that all water users whose supplies are interrupted shall be provided an alternate source. The impact of any temporary disruption in ground and surface water supply by construction related dewatering operations can be reduced through (a) advanced notification of potentially affected users and provision of alternate supply where needed, (b) rapid completion of activities, and (c) the application of effective erosion control at outfalls. Extraction of more than 50 m^3 per day will require a "Permit To Take Water" from MOEE.

Preparation of the Road Bed

- Any runoff from areas being compacted should be prevented from directly entering watercourses since surface compaction reduces soil infiltration capacity and encourages sediment laden overland flow. Sediment control measures (e.g impoundment, filtering) will be required to minimize the input of sediment into watercourses.

Surfacing

- Precautions should be taken to ensure that pavement construction does not result in watercourse contamination by such materials as lime, cement, oil and grease, asphalt, etc.

Bridges

- Bridge design should minimize the use of instream and nearstream substructures and should meet the approval of all appropriate government agencies (e.g. MOEE, MNR, Conservation Authority).

- Channel modification should cause minimal flow alteration, incorporate measures for the protection of stream banks and bed, and ensure that fish habitat is not degraded.

- The appropriate agencies (e.g. MOEE, MNR, Conservation Authority) should be contacted to ensure that all instream and nearstream activity is planned and carried out so as to cause minimal disturbance to fish, recreation, and any other local uses.

- Use "good housekeeping" precautions such as: acceptable disposal and stabilization of excavated, erodible material; use of protective dykes or cofferdams; maintenance of adequate channel capacity; erosion protection; bank stabilization; and designation of acceptable refuelling areas.

- Instream and nearstream work should be completed as rapidly as possible during the low streamflow period.

- The use of heavy equipment on stream bed or banks should be kept to a minimum to prevent damage to watercourse bed and banks. Where repeated crossings are required these should be confined to one location and should employ an armoured ford or temporary bridging.

- All near-channel grading operations (e.g. embankment construction) should incorporate immediate erosion protection and stabilization.

- Maintenance of existing structures (sandblasting, painting) should employ appropriate measures to ensure that materials either used or produced by the operations are contained and removed. The Ministry of Transportation should be consulted for detailed environmental guidelines on sandblasting and painting.

Site Restoration and Monitoring

- All mitigative measures should be monitored regularly to ensure continued effectiveness and all necessary maintenance should be undertaken immediately. Results of monitoring should be available for review by MOEE and/or other concerned agencies.

- Site restoration to as near preconstruction conditions as possible should be initiated and completed as soon as possible.

- Where necessary interim erosion/sediment control measures should be installed until long-term protection can be effectively implemented.

- The effectiveness of restoration measures (e.g. bank stabilization) should be monitored by the proponent and necessary maintenance should be undertaken promptly.

9.3 Sandblasting and Painting of Bridge Structures

Proper maintenance of bridge structures will require periodic sandblasting and repainting of structural steel components. Sandblasting has the potential of introducing considerable quantities of sand into the adjacent waterbody and will require measures to collect and control the sand and associated paint and steel debris. A number of methods exist for controlling these materials.

In most cases some type of enclosure system will be required to prevent the escape of debris. These may consist of partial enclosures, full enclosures, the incorporation of negative pressure along with some type of collection devices, and, in certain locations, skimmers may be required to intercept floating debris. The use of such devices is usually determined on a site-specific basis in consultation with MOEE and the Ontario Ministry of Transportation (MTO).

Collected debris usually contains a mixture of spent blasting medium (usually sand) and paint and rust. This material should be removed from the enclosures and from the skimmers in such a manner

that losses are minimized. Since this material is classified as a registerable solid waste, the material needs to be disposed of in an acceptable manner (a certified waste disposal site for non-hazardous material).

MTO, in conjunction with other agencies, is currently developing guidelines governing the use of these operations. In the interim, proponents and contractors must seek guidance from MOEE and MNR on a case-by-case basis.

10. SUB-AQUEOUS MINING

This generally refers to the removal of sand and/or gravel from the bed of a watercourse or the removal of beach material.

10.1 Impacts

a) Excavation could generate a significant degree of turbidity which may pose problems for water intake systems and actual disruption or siltation of adjacent areas may result in the loss of important aquatic habitats.

b) Removal of a source of beach feeding material could induce shoreline erosion and may result in the loss or degradation of important recreational areas.

c) Excavation may create deep holes where stagnant water conditions could occur.

10.2 Mitigation

a) In areas adjacent to water intakes or other sensitive water uses, work should be done in close cooperation with the water user.

b) Current patterns should be used advantageously to carry turbidity away from recreational areas or water intake systems.

c) In recreational areas work should not be conducted during peak use periods (usually June, July, and August).

d) Work should be scheduled so as to avoid fish spawning periods (the proponent should contact the local MNR office).

11. SURFACE and UNDERGROUND MINING

Surface mining, as opposed to underground mining, refers to such methods as strip mining, open-pit mining, hydraulic mining, etc. Strip mining is often used with reference to coal mining, where large amounts of overburden are removed to expose the underlying material to be extracted. The method of on-land mining for minerals is often referred to as open-pit mining. The minerals are usually found relatively close to the surface and compared to strip mining only a small amount of overburden has to be removed.

Open-pit mining results in a large open hole in the ground. The "waste products" are usually discharged in a specially designed "tailings area" and the overburden is stockpiled in areas adjacent to the pit. Quarries (mining of gravel for building products) are a form of open-pit mining. Underground mining does not usually result in the removal of overburden, though extensive tailing deposits can be produced.

11.1 Impacts

The effects of mining operations fall into two main classes:

1) physical effects: primarily due to sediments resulting from increased erosion after the land has been disturbed.

2) chemical effects: these include increased trace metal concentrations and acid formation from oxidation of leached minerals.

Both effects can commence in the initial stages of mining and can continue long after the mine has been abandoned. For these reasons adequate control measures should be part of the initial design.

Most control methods centre around the control of water to the site. Reduction of inflow of both surface

runoff and groundwater to the mine pit or waste areas (where leaching and erosion can occur) would greatly reduce the damage to adjacent watercourses. In order to minimize acid drainage from tailings areas or waste rock areas, chemical treatment (e.g., neutralization with lime) may be required.

The inflow of surface water runoff to the mine site may be eliminated by dyking, ditching, use of flumes, etc. to channel water away from pollutant bearing materials. Most metals occur in the sulfide form which is relatively insoluble in water but upon oxidation to the sulfate form they become readily soluble. Radioactive materials, such as that which result from uranium mill tailings, may be carried by wind or runoff into a watercourse where they continue to decay, releasing radioactivity.

Under natural conditions sulfide minerals undergo very slow oxidation due to the small amounts of oxygen diffusing through the soil and in other areas the mineral may be inundated by ground water, which usually contains low amounts of oxygen. Mining results in the sudden exposure of large quantities of sulfide minerals to the atmosphere and rapid oxidation takes place.

Mine tailings discharged into a tailings pond and inundated with water undergo slow oxidation because less oxygen is available compared to direct exposure to the atmosphere. Advocates of open water disposal for tailings must be cautioned that inundation by water does not stop the oxidation process.

In deep areas of a lake, which may already be experiencing low dissolved oxygen concentrations, tailings wastes will further reduce the dissolved oxygen levels.

Thus, besides the immediate impacts such as turbidity and release of chemical contaminants (trace metals, sulfates, etc) there are also potential long-term effects such as loss of bottom habitat, and continued release of contaminants as the tailings material oxidizes.

11.2 Mitigation

a) Obtain adequate information on the proposed site.

b) All access routes (road, power lines, water lines, etc.) should be clearly defined. Access roads should be sited for permanent use.

c) Use of pesticides, herbicides or defoliants to control biting insects or remove vegetation requires proper permits and supervision.

d) Surface water runoff to the mine site should be intercepted by placing impervious barriers (dykes) around the mine site, providing underdrains, using ditches, flumes, etc. to channel the water away from the mine site.

e) Clean material should be available to form the upper layer of regraded surfaces.

f) Preventive measures to minimize the amounts of sediments reaching a watercourse should be undertaken. These may include: diversion channels, desilting basins, soil compaction, vegetation cover, etc.

g) The mining operation should not cut into ground water recharge areas. If this cannot be avoided, ground water should be intercepted and diverted away from the pit. This may require pumping of the water, sealing a portion of the pit, grout curtains, recirculation, etc.

h) Potential highly erodible soils should be protected against erosion by special control measures (e.g., mulch, compaction, etc).

i) All material stockpiles should be adequately protected against erosion to prevent material from entering any watercourse.

<u>Tailings, Wastewater and Dewatered Wastes</u>

All discharges from treatment systems, tailings impoundments, etc, will require a Certificate of Approval from the local MOEE office.

a) Efforts should be made to avoid using natural watercourses for tailings disposal.

b) The tailings disposal area should be adequately dyked off to prevent the escape of contaminated materials to adjacent areas.

c) The minimum setback of the site from existing watercourses prescribed by Ontario Ministry of Natural Resources in relation to other activities such as forestry, should be adhered to.

d) Efforts should be made to reduce the quantity of waste water (e.g., reuse decant water) as much as possible.

e) Discharge of water from the tailings area to natural watercourses should be regulated according to the waste assimilation or dilution capacity of the receiving watercourses for given streamflows.

f) If discharge water of acceptable quality cannot be achieved by physical settling alone, additional treatment (e.g., chemical) or a combination of treatments should be undertaken. This may be necessitated by seasonal fluctuations in use, quantity and/or quality of the receiving water.

Dykes and Tailings Ponds

A containment area for tailings disposal should provide retention of solids and contaminants so that these materials will not enter any watercourse or cause detriment to adjacent areas.

I. Preliminary Considerations

a) Any area selected as a potential tailings disposal area should be thoroughly investigated for compatibility with existing and proposed uses.

b) Dyke design should be based on adequate soil, subsurface and stability analyses.

c) Dyke design and construction should be such that the dyke is safe and stable under all construction and operational phases of the tailings disposal area as well as upon closure of the site.

d) Tailings disposal areas to be built on marshy or other wetland areas should be fully approved by the Ontario Ministry of Natural Resources or other appropriate agencies.

e) Where necessary, prior approval must be guaranteed the proponent with regards to easement access or use of waterlots.

f) In areas where dyke failure could result in severe damage to neighbouring property, precautionary measures should be formulated well ahead of the actual disposal operation to deal with any emergency.

II. Capacity Considerations

a) The dykes and dyked areas should be constructed such that at any given time it will provide sufficient settling time to reduce suspended particulate matter to acceptable levels.

b) Provisions should be made for foundation and embankment settlement to allow adequate freeboard and prevent over-topping by waves.

III. Design and Construction Considerations

a) Trees, stumps, etc. in the path of the dykes should be cleared and grubbed. The subsurface conditions should indicate the need for overburden or organic material removal. The removal of overburden is necessary to ensure a solid footing or foundation for the dyke.

b) Access roads should be clearly defined and adjacent areas should not be subjected to unnecessary traffic or trampling.

c) The design features of the dyke must be such that it will not impose excessive stresses upon the foundation.

d) The slopes of the dykes must be stable under all construction and operational conditions, and upon closure of the site. Where necessary, the inner wall of the dyke should be protected against wave action.

e) Dyke designs should incorporate features that would minimize possible failures due to sinking or spreading.

f) Dykes built on shore close to rivers or streams should be located such that they will not result in lateral displacement of the river or streambank.

g) The dyke or containment area built into a stream should not restrict natural streamflow to the degree that upstream water levels will be raised or back water created or migratory paths blocked. Where such an activity is proposed, MNR will have to be consulted to ensure there are no adverse effects on fish habitat.

h) The use of heavy construction machinery should be restricted as much as possible to areas directly associated with the project.

IV. Operational Considerations

a) The inflow end of the tailings discharge should be located such that incoming material would not cause local scour of dyke or buildup of material near the outflow area.

b) The outlet sluice should be located so that there will be no short-circuiting of flow from the inlet.

V. Effluent Quality Considerations

a) If possible, adjustable weirs should be used instead of simple outfall pipes to provide adequate detention time and water quality control.

b) Where feasible, a layer of low cover vegetation should be left intact between the outfall and receiving watercourse to provide additional entrapment of particles.

c) In instances where the water within the containment area contains debris or surface films, skimming devices should be installed in the discharge area. Where necessary to guarantee effluent of acceptable quality, the containment area must be provided with multiple settling basins.

d) In cases where the effluent from the outfall leads to a ditch prior to the watercourse proper, the ditch should be protected as necessary to prevent scouring and turbidity.

e) Consideration should be given to the use of additional treatment methods, such as chemical coagulation, where conventional settling procedures are not adequate.

f) Water quality of the effluent shall be such that the Ministry of Environment and Energy's published permissible criteria for receiving stream are not violated (PWQO/G).

11.3 Maintenance Considerations

a) The passage of seepage flow through the dyke and foundation must be controlled, so that piping, sloughing and the removal of material by solution do not occur.

b) Measures must be taken to stabilize the following conditions: - cracks in slopes, bulging and slumping on slopes, excessive pore pressure, wet spots and seepage on outer slopes, erosion of slope protection, excessive settlement and horizontal movement.

c) Where simple outfall pipes are used, measures such as installation of trash screens must be taken to ensure that they do not become plugged.

d) The faces of all slopes should be properly protected by vegetative cover, berms, riprap, etc.

Note: Under the revised Mining Act, closure plans are also required for all new and existing mines to address rehabilitation of the site.

12. FORESTRY PRACTICES

Forestry activities can potentially contribute soils and contaminants to nearby watercourses from a number of activities. These include access road construction, felling practices such as clear-cutting,

pesticide use, prescribed burning and other site preparation methods, and equipment servicing. All activities should be well planned with appropriate management plans in-place before any activity commences.

12.1 Access Roads.

Forestry access roads are constructed to provide access for equipment to the harvesting site. Such roads are usually designed for finite use to the end of the harvesting period and are not constructed to all-weather standards. The Ministry of Natural Resources has prepared a handbook for the construction of access roads in relation to stream and river crossings (Environmental Guidelines for Access Roads and Water Crossings, 1990).

a) Planning Considerations

The planning stage represents the first level at which the effects of road construction can be mitigated. By carefully considering the location of access roads, many of the adverse effects of access roads can be avoided.

- examine topography for the best access routes (i.e. level terrain away from waterbodies)
- the planning exercise should seek to minimize the number of water crossings.

b) Design Recommendations

Design of the road should be appropriate to the terrain. Where water crossings cannot be avoided, the locations for crossings should be carefully chosen. Additional design considerations for the construction of access roads includes:

- Alignment
  - provide maximum cross-drainage. This will help to ensure minimum down-road flow and reduce erosion of the road surface.
  - locate road to lay lightly on land, minimizing cut and fill while maintaining proper road standards.
  - avoid locations below high water mark.

- Water Crossings. Water crossings may be temporary or permanent.
  - choose locations where crossing will minimize amount of streambed disruption, or where streambeds are composed of firm cohesive soils or rock.
  - choose areas where approaches have low slopes and short slope lengths.
  - design culverts and bridges to accommodate expected flows and to allow fish migration.
  - restrict construction activity in water to periods of low flow and to avoid fish spawning periods.

- Drainage. Proper drainage will minimize the potential for erosion of the road.
  - use grade rolls or dips to reduce down-road flow of surface water
  - drain surface water to vegetation or filter strips, not directly to watercourse
  - use cross-drains, culverts, off-take ditches to avoid carrying water long distances.

c) Construction Recommendations

Appropriate construction techniques would include matching the construction method to the terrain to minimize the loss of sediment.

- Clearing
  - see road construction, Section 9.
- Excavation
  - shape inslopes and backslopes to 2:1 or 1.5:1 or flatter for stability (depending on material).
  - compact material.
  - deposit excess material in stable locations above high water mark.
  - shape and stabilize borrow pits.
- Surfacing
  - where steep grades exist, road should be surfaced with materials that will minimize erosion and washout.
- Drainage
  - provide adequate drainage during construction to minimize erosion of unconsolidated material.
  - install culverts in the dry by avoiding flowing water where possible. Use compacted granular material.
  - ensure culvert slope matches stream gradient.
  - armour culvert inlets and outlets where necessary.
  - provide subsurface drainage in areas of slope instability.
  - use vegetation/filter strips or silt fencing

where roads are close to water.

- Soil Protection
  - stabilize exposed areas as soon as possible.
  - use silt barriers prior to establishment of vegetation cover.

Detailed information on design and construction are included in the handbook "Environmental Guidelines for Access Road and Water Crossings" (1990) available from the Ontario Ministry of Natural Resources.

12.2 Harvesting

Harvesting refers to the cutting, felling and hauling of timber and can involve considerable disruption of the land surface. How these activities are undertaken can affect the loss of sediment.

Certain harvesting methods, such as clear-cutting, can result in considerably more sediment reaching watercourses than other, more selective methods of harvesting. The Ministry of Natural Resources has prepared two publications to minimize impacts of timber harvesting practices: "Timber Management Guidelines for the Protection of Fish Habitat" and "Code of Practice for Timber Management Operations in Riparian Areas".

- establish filter strips between harvesting area and waterbodies.
- minimize soil disturbance and exposure within the filter strip.
- locate landing and skid trails outside the filter strips.
- avoid felling trees into non-forested wetlands.
- keep logging residue out of watercourses.
- winch logs on steep slopes where conventional skidding may result in erosion.
- install vegetation strips, fill in ruts and install water bars and erosion barriers where necessary.
- remove any obstructions in water courses, stabilize soil along banks.
- inspect and maintain erosion barriers regularly.

12.3 Mechanical Site Preparation.

Site preparation involves those activities necessary to prepare the area for planting and can involve scarification, raking, discing, etc. In many respects this is similar to agricultural practices for soil preparation.

- use techniques that will cause minimal disturbance and erosion
- establish adequate filter strips
- residues from shearing and raking operations should be deposited in stable areas
- locate windrows outside filter strips and so as not to interfere with natural drainage
- follow land contours when discing

12.4 Pesticide Use

Pesticides are used in forest management and the maintenance of rights-of-way to control insect pests and weeds. Since loss of chemical pesticides to watercourses can result in degradation of water quality and adverse effects on biota, efforts should be made to minimize such losses wherever possible.

- Integrated Pest Management (IPM)- use of pesticides should be part of an overall IPM program to minimize loss of pesticides.
  - the use of pesticides should be carefully controlled, such that pesticides are applied only as needed.
  - application should be done in conjunction with other non-chemical pest control measures.

- Pesticides - do not exceed the recommended label rate and do not overspray.
  - select application methods that do not broadcast the pesticide.
  - do not fill mixing/ application equipment directly from water unless equipped with anti-backsiphoning devices.
  - establish buffer zones while spraying; spraying in the buffer zone is not permitted.
  - where aerial spraying is used, aircraft should avoid spraying over waterbodies. (Where stream crossings cannot be avoided, spraying should be at right angles to the watercourse).
  - clean equipment where residues will not enter watercourses.
  - do not clean equipment in surface waters.

The proponent should contact MOEE and MNR regarding the necessary licenses and permits for pesticide application.

12.5 Prescribed Burning

Controlled burning is used to reduce the hazard of wildfire; to facilitate site preparation by reducing debris; and to release nutrients and eliminate unwanted vegetation. Any burning operation must receive the necessary permit from the appropriate agency.

- use natural fire barriers (e.g. road) whenever possible
- locate firelines such that they follow contours whenever possible. Firelines should be constructed such that drainage is directed to a settling area and not directly into a waterbody.
- establish filter strips (minimum width 100 ft (30 m)).
- avoid placement of piles for burning near watercourses which may result in destruction of ground cover and organic soil layer, lowering infiltration.
- maintain erosion control measures on firelines (seeding, etc).

12.6 Equipment Management

This includes maintenance of field equipment, including fuelling and servicing. Most forestry equipment will not be removed from the site for servicing and thus the potential for loss of servicing fluids (oils, diesel fuel, gasoline, etc) either directly or indirectly to water courses can be high. These can introduce contaminants to the water resulting in degradation of water quality.

- fuelling, maintenance
  - designate specified area for equipment maintenance. All waste lubricants, fuels, etc should be collected and transported off-site for proper disposal
  - provide maintenance vehicle with necessary equipment to collect and store lubricants during regular maintenance or breakdowns.
  - locate fuelling and maintenance away from water

The Ministry of Natural Resources and the timber industry have co-produced a video, available from MNR, based on the "Code of Practice for Timber Management Operations in Riparian Areas" to enhance awareness of environmental concerns and best management practices.

13. LANDFILL CONSTRUCTION

The construction and operation of landfill sites can result in significant loss of sediment to nearby watercourses. Many of the construction practices are similar to urban development in that ground cover is stripped from the site and stockpiled for future use as daily cover or for capping the landfill.

13.1 Potential Impacts

Landfill construction and operation involves a number of unit operations that can contribute to sediment loss. In a typical landfill, the site is first prepared by stripping the existing cover. The site may also be excavated to a certain depth and lined with a variety of materials (clay, plastic, etc.), depending on the final use of the site. The material removed is stockpiled around the perimeter of the site, and is used either for daily cover and/or for final capping of the site.

Potential impacts from sediment erosion include:

- sediment from stockpiled soils and from exposed ground being carried to nearby watercourses;
- wind blown dust during dry periods; and
- mud tracking onto nearby roads.

In addition to sediment impacts there are a number of other concerns that need to be addressed as well. All of these are described in detail in the MOEE document "Guidance Manual for Landfill Sites Receiving Municipal Waste" (November 1993).

13.2 Mitigation of Impacts

A number of best management practices developed for urban construction can be used effectively to control sediment loss from landfill sites.

Planning

The effects of landfill construction can best be mitigated during the planning stage.

a) The landfill should be located to avoid critical areas such as shorelines, floodplains, natural drainageways, steep slopes and erodible and porous soils.

b) Buffer strips should be maintained between the site and any watercourses

b) Appropriate stormwater management needs to be designed into the project, rather than added on at the end.

Construction

a) Stockpiled soils should be located away from watercourses and stabilized against erosion as soon as possible. The outer slopes and crowns of all berms should be stabilized with permanent vegetation.

b) Run-off should be diverted away from all active disposal areas. Where possible, storm flows should be diverted around the landfill site.

c) On-site or downstream stormwater treatment measures will be necessary to control runoff and associated sediment losses from the site before they reach watercourses. These would include a number of measures such as settling ponds, detention ponds, filter strips, filter fences, infiltration basins and grassed swales. These are discussed in detail in Section 5.

d) Vehicles should leave the site at designated points that is provided with a bed of non-erodible material of sufficient length to ensure that a minimum of material (mud) is tracked off the site and onto adjacent roads.

e) Upon closure of the site, all disturbed areas should be stabilized and protected against erosion as soon as possible.

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